Technical Report HL-96-3
July 1996

US Army Corps of Engineers
Waterways Experiment Station

Geoacoustic Study of New Jersey Coast from Townsends Inlet to Hereford Inlet

by Richard G. McGee, Darla C. McVan

Prepared for U.S. Army Engineer District, Philadelphia

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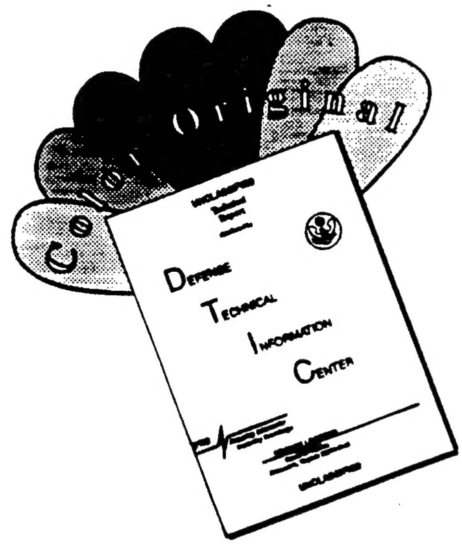

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U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
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Final report

Prepared for U.S. Army Engineer District, Philadelphia
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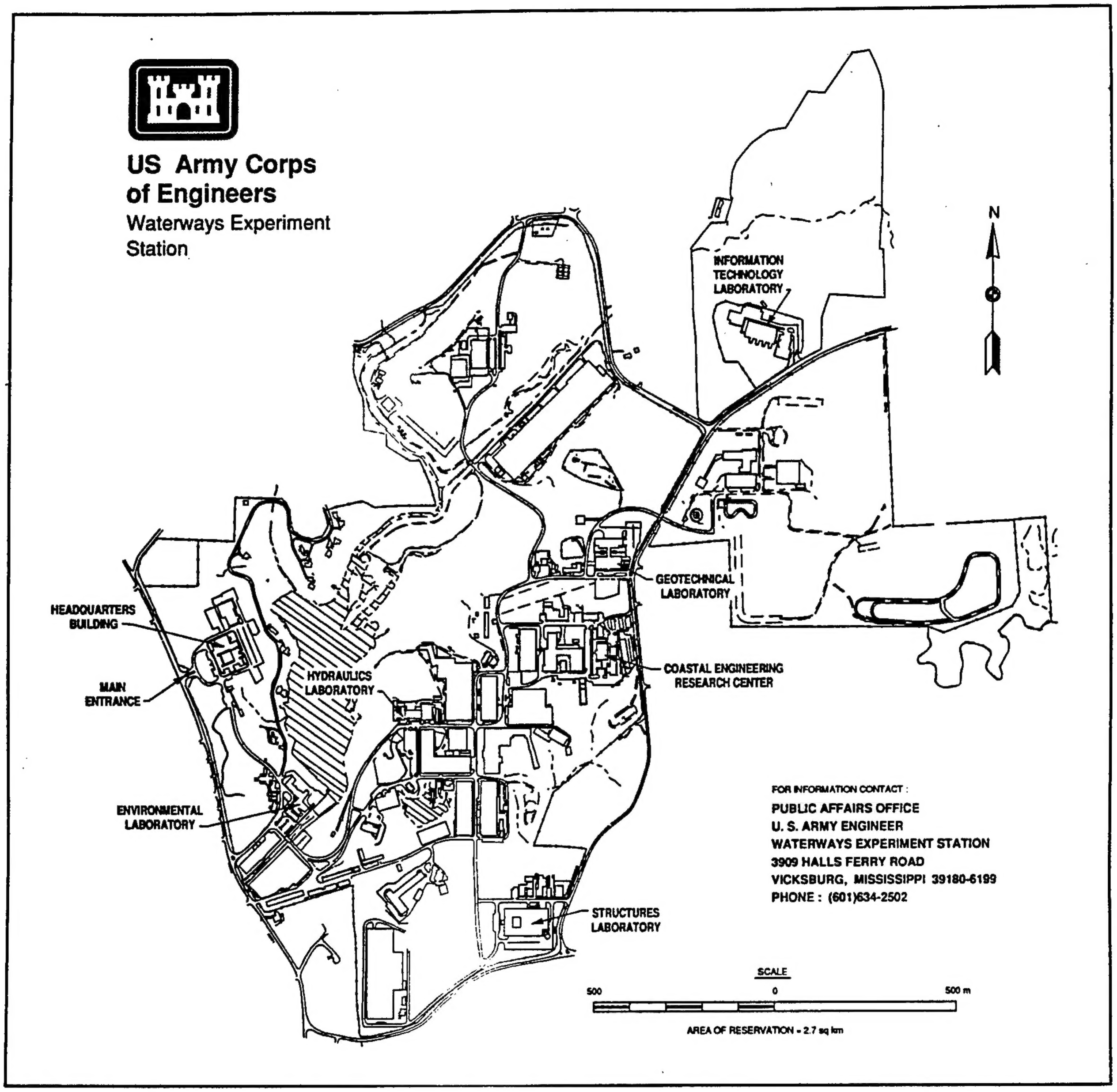

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Preface

A geoacoustic study of the New Jersey coast from Townsends Inlet to Hereford Inlet was conducted by personnel of the Hydraulics (HL) and Geotechnical (GL) Laboratories, U.S. Army Engineer Waterways Experiment Station (WES). The field work was performed during September 1992. The investigation was performed under sponsorship of the U.S. Army Engineer District, Philadelphia (NAP). The NAP Project Engineer was Mr. Brian Murtaugh.

The overall test program was conducted under the general supervision of Mr. F. A. Herrmann, Jr., Director, HL; Mr. G. A. Pickering, Chief, Hydraulic Structures Division (HSD), HL; and Dr. B. J. Brown, Chief, Hydraulic Analysis Branch (HAB), HSD. Mr. Richard G. McGee, HAB, was the Principal Investigator. This project is a cooperative effort with the Geotechnical Laboratory under the supervision of Drs. W. F. Marcuson III, Director, GL, and A. G. Franklin, Chief, Earthquake Engineering and Geosciences Division (EEGD), GL. This report was prepared by Mr. McGee and Ms. Darla McVan, HAB, under the supervision of Mr. R. A. Sager, Chief, Programs and Operations Office, HL. Instrumentation support was provided by Mr. Tom S. Harmon, Jr., EEGD, and by Messrs. David D. Caulfield and David C. Caulfield of Caulfield Engineering, Oyama, BC, Canada. Data analysis assistance during this study was provided by Mr. Rodney L. Leist, EEGD; Ms. Janie M. Vaughan, HAB; and Mr. Brian Williams, Computer Sciences Corporation, Vicksburg, MS. Technical assistance was also provided by Dr. D. K. Stauble, Coastal Geology Unit, Coastal Engineering Research Center, WES.

Acknowledgement is made to the captain and crew of the Research Vessel *Cape Henlopen*, and administrative personnel of the University of Delaware, College of Marine Studies, for their support in performing the field surveys.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	25.4	millimeters
miles (U.S. statute)	1.609347	kilometers
miles (U.S. nautical)	1.852	kilometers

1 Introduction

Background

The U.S. Army Engineer District, Philadelphia, is currently preparing a feasibility report for shore protection solutions for the Atlantic coast of New Jersey. The report is to include studies of eroding areas of coastline to provide adequate shore protection solutions in the form of structures and beach fill. One specific task in this study is to investigate offshore marine sediments for potential borrow areas for use as sources of beach-fill materials. An area currently under study is a 7-mile[1] stretch of coastline extending from Townsends Inlet to the north to Cape May Inlet to the south (Figure 1). No subsurface information exists for this stretch, which the Philadelphia District has identified for subsurface exploration.

The U.S. Army Engineer Waterways Experiment Station (WES), specifically the Coastal Engineering Research Center (CERC), has conducted investigations south of the project area in the region off Cape May, NJ (Meisburger and Williams 1980), and even further south as part of the Ocean City Hurricane Protection Project (Anders and Hansen 1990). These studies resulted in the identification of sediments for beach renourishment purposes in these regions. Therefore, as an initial step to the feasibility report investigation, it was decided that a comprehensive subsurface exploration program using acoustic subbottom profiling and vibracore sampling be initiated to better establish possible limits of available granular material.

WES has developed a high-resolution seismic reflection technique to quantitatively assess the characteristics of bottom and subbottom marine sediments. The technique uses impedance structures to describe naturally occurring marine sediments in terms of their engineering properties, i.e., density, mean grain size, soil classification, providing a contiguous picture of the horizontal and vertical extents of those properties. The Philadelphia District requested application of this technique in support of the New Jersey coast feasibility study.

[1] A table of factors for converting non-SI units of measurement to SI (metric) units is found on page viii.

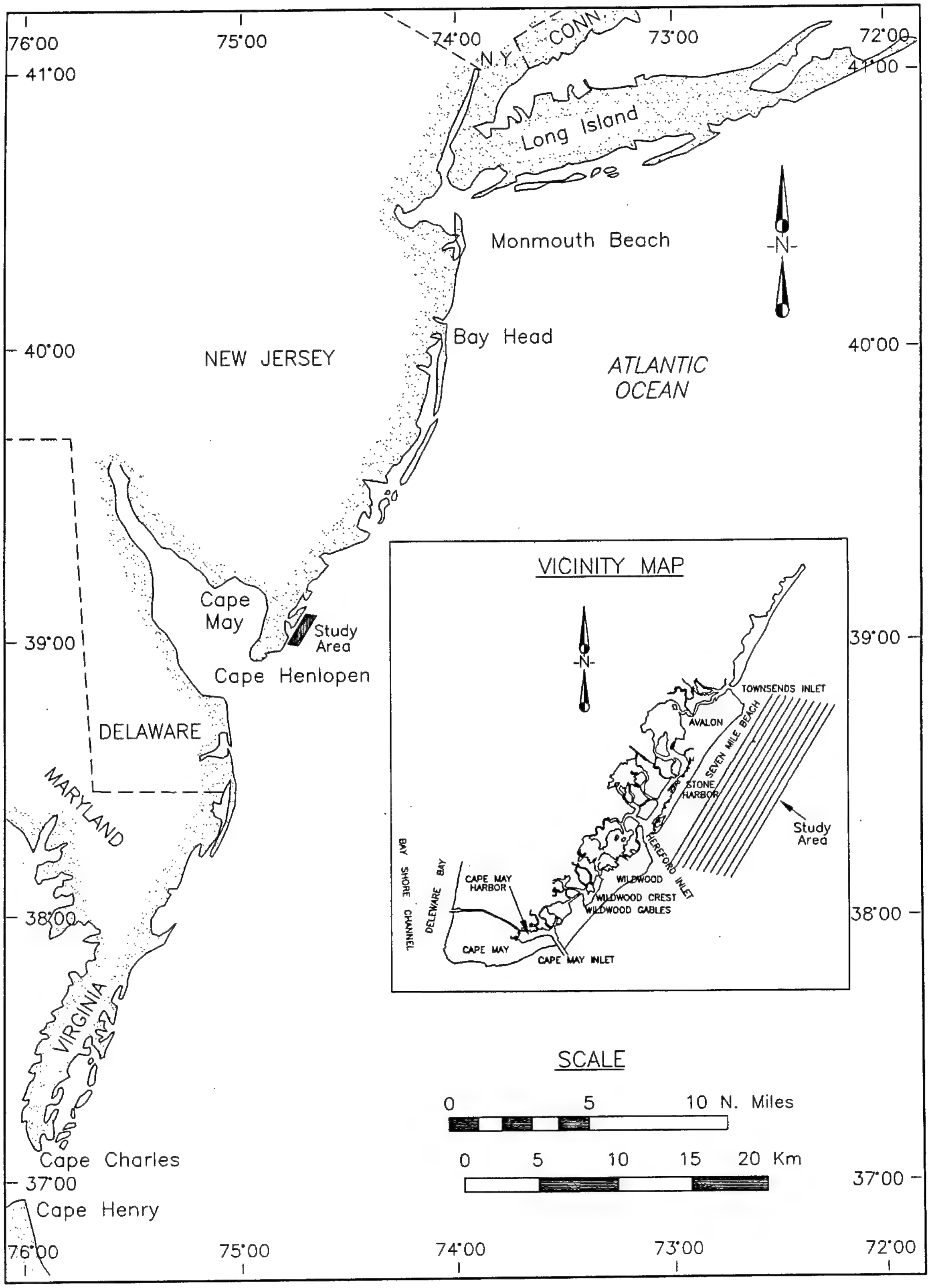

Figure 1. New Jersey coast vicinity map and study area

This study was performed in conjunction with another geoacoustic study by WES (McGee 1995) conducted offshore of the Delaware coastline between Cape Henlopen, DE, and Fenwick Island for the Philadelphia District, which resulted in identification of several areas cited for further evaluation as beach fill. The seismic data acquisition for this study was accomplished concurrently with the Delaware coast mobilization.

Geologic Setting

As presented by Meisburger and Williams (1980), the coast of New Jersey can be divided basically into two physiographic parts. The northern part from Monmouth Beach to near Bay Head is a headland where older coastal deposits are in direct contact with the sea. The central part of the coast comprises low-lying sandy barrier islands and spits backed by shallow lagoons. The barriers are fairly continuous except for nine tidal inlets, and extend in an irregular line south through the study area to Cape May City. As summarized by Morang and Pope,[1] the dominant factor shaping the northeast coast during the Holocene Epoch has been marine transgression, or the "spread of the sea over land areas." The coastal zones were inundated by the sea as the continental ice sheets melted, releasing enormous volumes of water to the oceans. The rise was accompanied by erosion and shoreline retreat along most of the coast, resulting in a highly variable coastal morphology of headland beaches, drowned river valley estuaries, and remnant beach deposits stranded offshore. In general, these remnant beach deposits are shoals composed of Holocene sands and gravels, the sediments most likely to be suitable beach fill. Pre-Holocene seafloor sediments consist of reworked surface sands containing significant percentages of fine materials and are heterogeneous in character and discontinuously distributed.

Objective

The objective of this investigation is to quantify the bottom and subbottom sediments in terms of in situ density, mean grain size, and soil type to a depth of about 20 ft below the ocean bottom, where possible, for a 3-mile-wide area between Townsends Inlet and Hereford Inlet along the New Jersey coast (Figure 1). The results are intended to provide initial estimates of the sediment characteristics for the purpose of defining the limits of available granular materials. Acoustic reflection profile data will facilitate the accurate positioning and optimal placement of vibracore borings by providing near continuous coverage of the entire area of interest. The acoustic data and physical sediment data will be combined to characterize the lateral and vertical extents of the sediments within this project area. Based on this characterization, specific

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1 A. Morang and J. Pope. (1993). "Preliminary geomorphic evaluation of potential sand resource areas, offshore of the Delmarva Peninsula," Memorandum for Record, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

areas will be cited for detailed evaluations. The results of this phase of the study are not intended to provide assessment as to the suitability of any marine sediment as beach quality material; rather, they are intended to isolate areas for further detailed investigation.

2 Geophysical Approach

The technique used to quantitatively assess the characteristics of the sediments along the New Jersey coast is a modified seismic reflection technique that relates the engineering properties of sediments to acoustic impedance by precisely determining the reflection coefficient at each reflection horizon. This Acoustic Impedance (AI) method is discussed in detail by McGee, Ballard, and Caulfield (1995) and in McGee, Ballard, and Sjostrom references in the Bibliography. However, it is necessary to briefly describe the method as it applies to the New Jersey coast project. Acoustic theory is discussed only in sufficient detail to enable the reader to understand basic concepts. Specific processing and analysis details will be discussed in Chapter 6.

The AI method is an extension of the techniques developed by Caulfield and Yim (1983) and Caulfield, Caulfield, and Yim (1985) for the identification of subbottom marine sediments. Modelled after Hamilton's approach to geoacoustic modelling of the seafloor (Hamilton 1980), this empirical technique compensates for absorption in each layer as a function of the center frequency of a band-limited seismic trace. It corrects for spherical spreading and uses classical multilayer reflective mathematics to compute reflection coefficients at the sediment horizons. The reflection coefficients are converted to impedances and classified according to established relationships between the acoustic impedance and the geotechnical properties of marine sediments, thereby classifying the lithostratigraphy. Figure 2 illustrates the general processing steps required by the method in practice.

Reflectivity and Acoustic Impedance

As energy generated from an acoustic source in the form of a plane wave arrives at a boundary between two materials with differing properties, part of the energy will be reflected back toward the surface and part transmitted as presented in Figure 3. A portion of the transmitted energy will undergo absorption or attenuation in the layer while the remainder propagates through to the next stratigraphic boundary. According to Snell's law for the case of normal-incidence compressional (P-wave) propagation across the boundary of a horizontally oriented system and for continuity of displacement and stress,

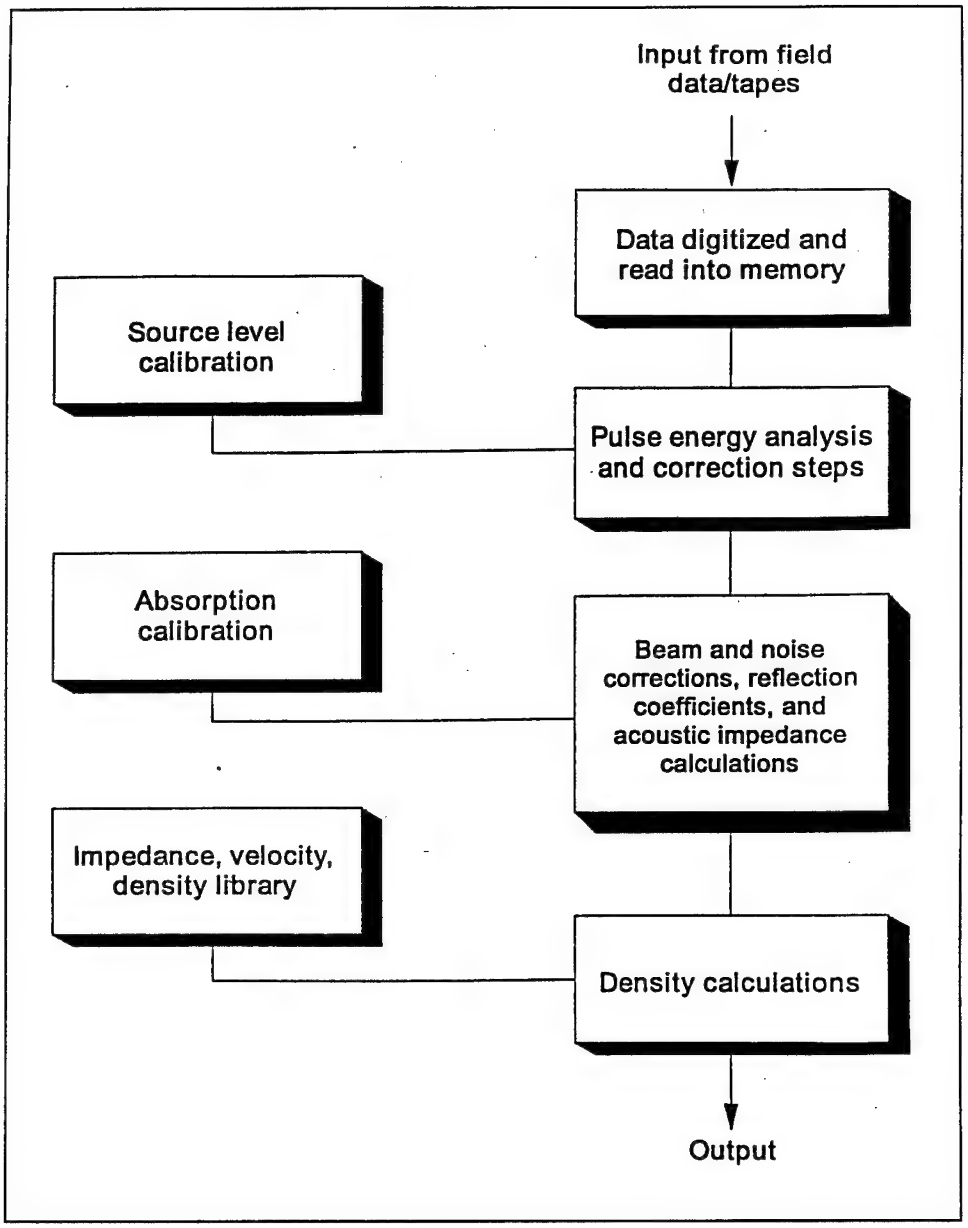

Figure 2. AI processing flowchart

the relationship between the incident (A_i), reflected (A_c), and transmitted (A_t) waves can be expressed as

$$A_i - A_c = \frac{E_2/v_2}{E_1/v_1} A_t \tag{1}$$

where E_1 and E_2 are the elastic moduli of media 1 and 2, respectively. For a perfectly elastic medium $E = \rho v^2$, where ρ is the mass density and v the

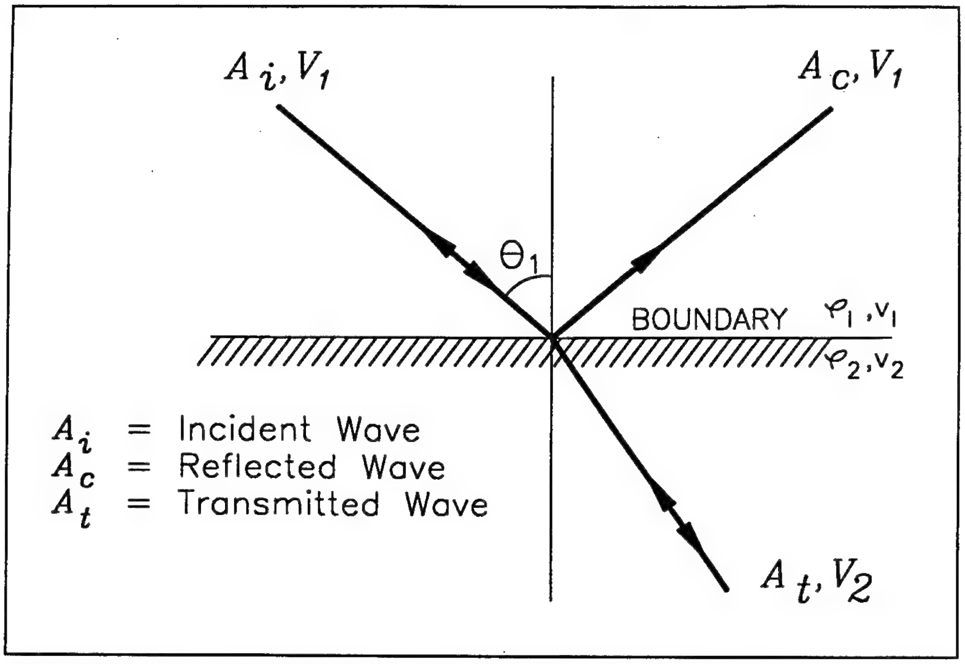

Figure 3. Acoustic wave propagation at a boundary between two interfaces; Snell's law

elastic P-wave velocity. The quantity ρv is called the *acoustic impedance*, Z, of the medium and thus represents the influence of the medium's characteristics on the reflected and transmitted waves. The reflection coefficient R is defined as the percentage of the wave's reflected energy. The acoustic impedance and the reflection coefficient are related through the Zoeppritz equation (Zoeppritz 1919) as

$$Z_2 = Z_1 \frac{(1 + R)}{(1 - R)} \tag{2}$$

where Z_1 and Z_2 are the acoustic impedances of the first and second media, respectively. This relationship provides a straightforward method for determining acoustic impedance. By knowing the first Z and the succeeding R's, one can then calculate all the acoustic impedances. In this case, the first layer is always seawater, which has a known typical impedance value of 1,494 $\times 10^2$ g/cm^2 sec. By calculating the remaining R's, the problem is solved.

Polarity of Reflection Coefficient

The nature of the impedance change (higher or lower) at a reflection horizon will produce either a positive or negative reflection coefficient. A negative reflection coefficient results from the phase change of the reflected signal occurring when the wave reflects off a softer layer. This phenomenon

is described mathematically by rearranging Equation 2 to solve for R resulting in

$$R = \frac{Z_2 - Z_1}{Z_1 + Z_2} \tag{3}$$

It is readily apparent that whenever the impedance of the upper layer, Z_1, is greater than the impedance of the lower layer, Z_2, R becomes a negative number.

Techniques have been developed to assess the reflection sign, each dependent upon the type of acoustic signal used to insonify the sediments. For wide-band frequency-modulated pulses, such as "Chirp" systems, the polarity of R is assessed using match-filter correlation techniques[1] to correlate the source wavelet with the reflected wave. Since no wide-band sonars were used for this study, a new approach was devised to exploit the pulse characteristics of band-limited acoustic pulses, relying heavily on statistical analysis rather than the aforementioned deterministic approach.

By shaping the transmit pulse into a Gaussian shape, a peak amplitude can be detected as shown in Figure 4. After the peak amplitude of the first

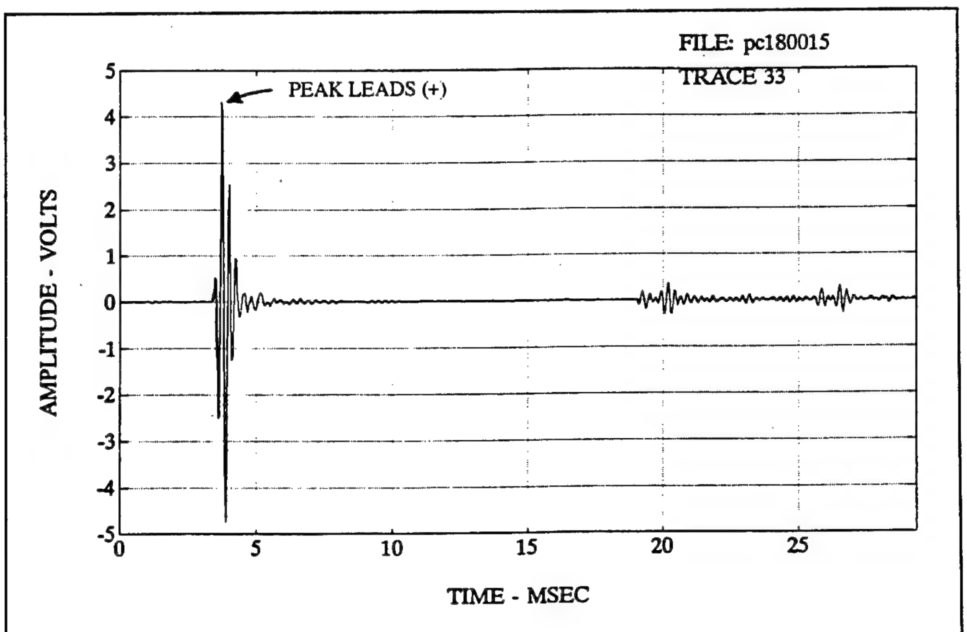

Figure 4. Shaped transmit pulse

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1 Correlation technique used is described in Caulfield (1991a) and McGee, Ballard, and Caulfield (1995).

bottom signal is detected, a determination is then made of its polarity. Except for the case of organics, the surface material reflectivity is always assumed positive since sediment structures usually have a higher impedance than seawater. Once the polarity is determined, the entire signal is scanned in the energy domain, on data above the minimum signal-to-noise (S/N) ratio, and the peak is located at each reflecting horizon. Once the peak is found, the data are returned to the time domain, and the peak signal is determined to be positive or negative. The method uses integration constants to handle noise; however, in the presence of noise, the technique is not guaranteed to produce perfect results. It has been found, though, that by averaging results over many sequential traces, fairly reasonable results can be obtained, again showing the importance of high S/N data. This technique was used in the analysis procedure for the New Jersey coast study.

Acoustic Impedance Modelling and Absorption

The relationship between acoustic impedance and specific soil properties has been empirically derived from world averages of measured impedance versus sediment characteristics (Hamilton 1970a, b; 1972a, b; 1980; Hamilton and Bachman 1982). Further development of statistical models and algorithms (Caulfield and Yim 1983) establishes relationships between acoustic impedance and soil properties (porosity, bulk density, mean grain size, etc.) for sediments within various natural marine environments and allows the identification and characterization of the subbottom layers from acoustically derived seismic reflection data.

Processing of the seismic data involves determining the precise reflection coefficient at each detectable reflection horizon. This requires that the major losses associated with acoustic wave propagation in a layered sediment environment be properly accounted. These losses include (a) transmission loss due to spherical spreading, (b) transmission through reflectors, and (c) intrinsic absorption within a particular sediment unit. Each of these losses is assessed using processing and analysis tools developed specifically for the AI method. These tools include the Acoustic Core System (Caulfield 1992), the Digital Spectral Analysis System (Caulfield 1991b), the Digital Shallow Seismic Processing and Correlation System (Caulfield 1991a), and in-house WES programs for equipment calibrations and bottom surface analysis using the sonar equations.

Seismic reflection signatures are not universally unique; i.e., several combinations of geologic conditions could conceivably yield similar signal characteristics resulting in similar impedance values. But in a given geologic setting, such as the New Jersey region along the Inner Continental Shelf, a particular sediment usually has a characteristic, relatively narrow range of impedance values. Therefore, project-specific calibrations are used to relate specific acoustic signatures to respective reflectors. Using calibration procedures incorporating the vibracore sample data, the acoustic reflection data are processed to yield accurate acoustic impedance values at reflection

horizons for the geologic region of interest. The geoacoustic calibrations for the New Jersey coast project are discussed in Chapter 5.

3 Survey and Equipment

As stated in Chapter 1, the seismic data acquisition phase of this study was accomplished during field mobilization for the Delaware coast study. Seismic operations for both studies are identical. All position coordinates are presented in North American Datum of 1983 (NAD 83), New Jersey State Plane coordinates. Weather conditions during the New Jersey survey were much improved from the Delaware coast survey, providing improved S/N data, enhancing the ability to estimate sediment properties.

Survey

The New Jersey coast survey consisted of ten profile lines, each approximately 7 miles long, oriented parallel to the shore as shown in Figure 5. This orientation was chosen to achieve maximum survey efficiency in keeping with the study objective: identification of detail study areas for beach-fill sediments. The lines are spaced at approximately 1,640-ft intervals beginning about 1 mile offshore and ending near the 3-mile limit. Each survey line is numbered sequentially beginning nearshore at line NJ00, ending at line NJ09 farthest offshore. The labelled dots displayed on the survey lines in Figure 5 are selected seismic data file numbers. These are included to assist in correlating the reflection profile data with the survey position data. These data formats are discussed in Chapter 4. The survey direction is indicated by increasing data file number. The sediment profiles are presented according to the line numbers shown.

Equipment

Survey vessel

The survey was conducted aboard the Research Vessel *Cape Henlopen* operated by the University of Delaware, College of Marine Studies, Lewes, DE. Figure 6 presents the general arrangement of the main deck. Locations of the geophysical equipment, fathometer, and navigation antenna are shown. Details regarding each piece of equipment are discussed in the following sections. The recording area was located in the dry laboratory on the port side of the main deck.

Navigation and bathymetry

The navigation and high-frequency bathymetry information for the survey was provided by Gahagan and Bryant Associates. A differential global positioning system (DGPS) was employed for horizontal positioning. The DGPS equipment consisted of a Trimble Navigation 4000 RL II DGPS reference station, Trimble Navigation 4000 DL II mobile GPS receiver, and a Dataradio radio/modem link differential correction data link. The equipment is rated at providing horizontal accuracy of ± 1 to 3 m root mean square (RMS) (68 percent of the time).

Bathymetry was provided by the Krupp Atlas Deso 20 fathometer. A single high-frequency transducer, 210 kHz, was used for sounding. The fathometer was located off the port side as shown in Figure 6. The fathometer was calibrated at the start of the project by the standard bar check method. Tide data were obtained by the Philadelphia District from National Oceanic and Atmospheric Administration tide gage 8534720 at Atlantic City, NJ, and postprocessed with the fathometer data to arrive at depth elevations (el) in feet referenced to mean lower low water (mllw).

The navigation and bathymetric equipment were interfaced with a Hewlett Packard 310 computer to record and provide real-time navigation information. Additional interfacing included a serial connection for the output of position coordinates and high-frequency bathymetric data directly to the digital seismic data acquisition system. Figure 6 presents the navigation system geometry on the survey vessel.

Geophysical equipment

The acoustic subbottom reflection records were generated using a 3.5-kHz high-resolution "pinger" system and an integrated, high-definition 400-Hz to 5.0-kHz "boomer" system. The specific systems used were as follows.

3.5- to 7.0-kHz pinger system. This system allows the transmission of variable-length acoustic pulses (0.2-3 msec) of 3.5- and 7.0-kHz frequencies. Power levels can be varied from 1 to 10 kW. However, depth of penetration can be limited in areas of highly competent sediments. For the New Jersey coast survey, the operating parameters that provided the optimum S/N ratio, resolution, and depth of penetration were as follows:

a. Power setting: 5 kW

b. Frequency: 3.5 kHz

c. Pulse length: 1 msec

d. Ping rate: 0.25 sec

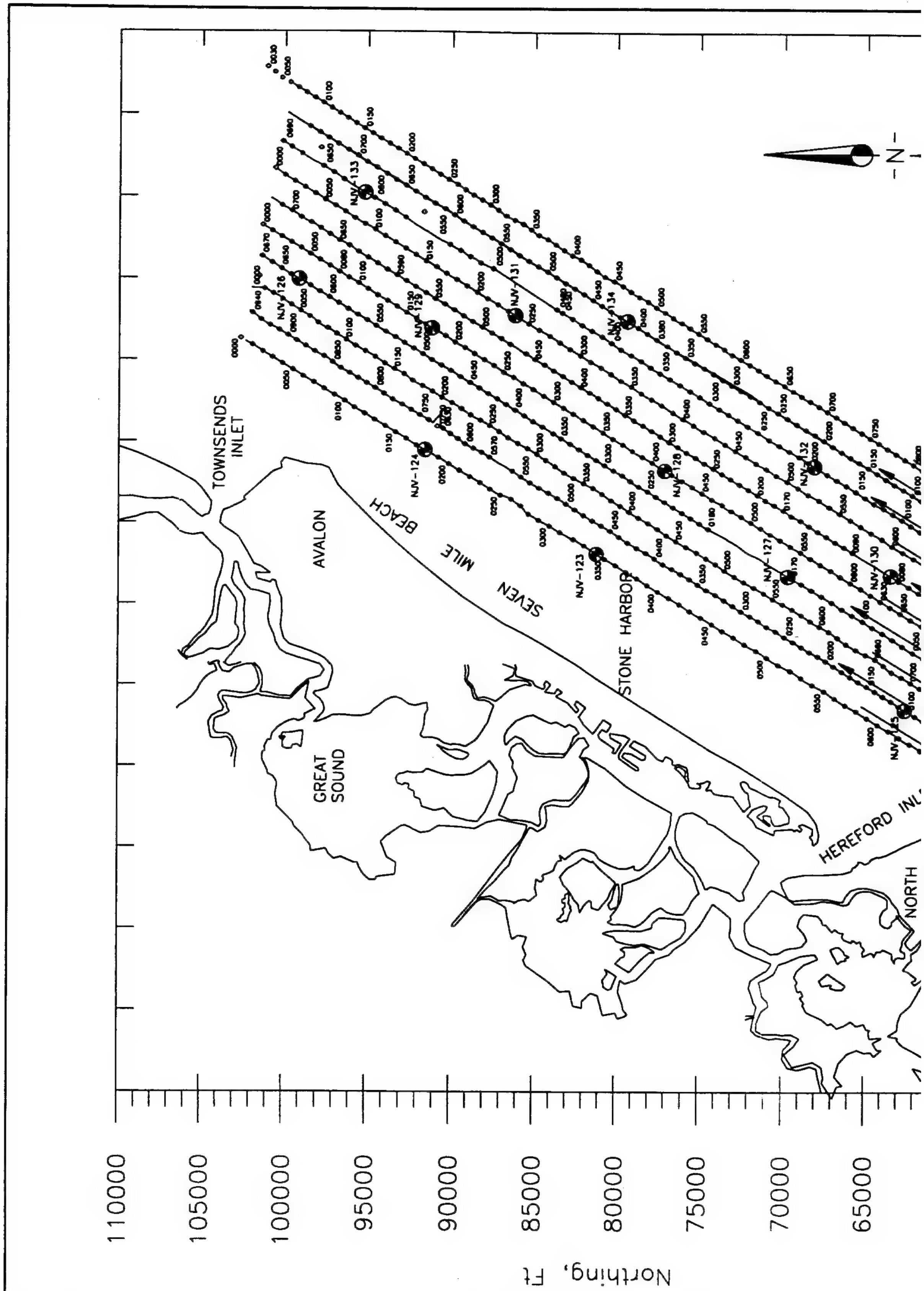
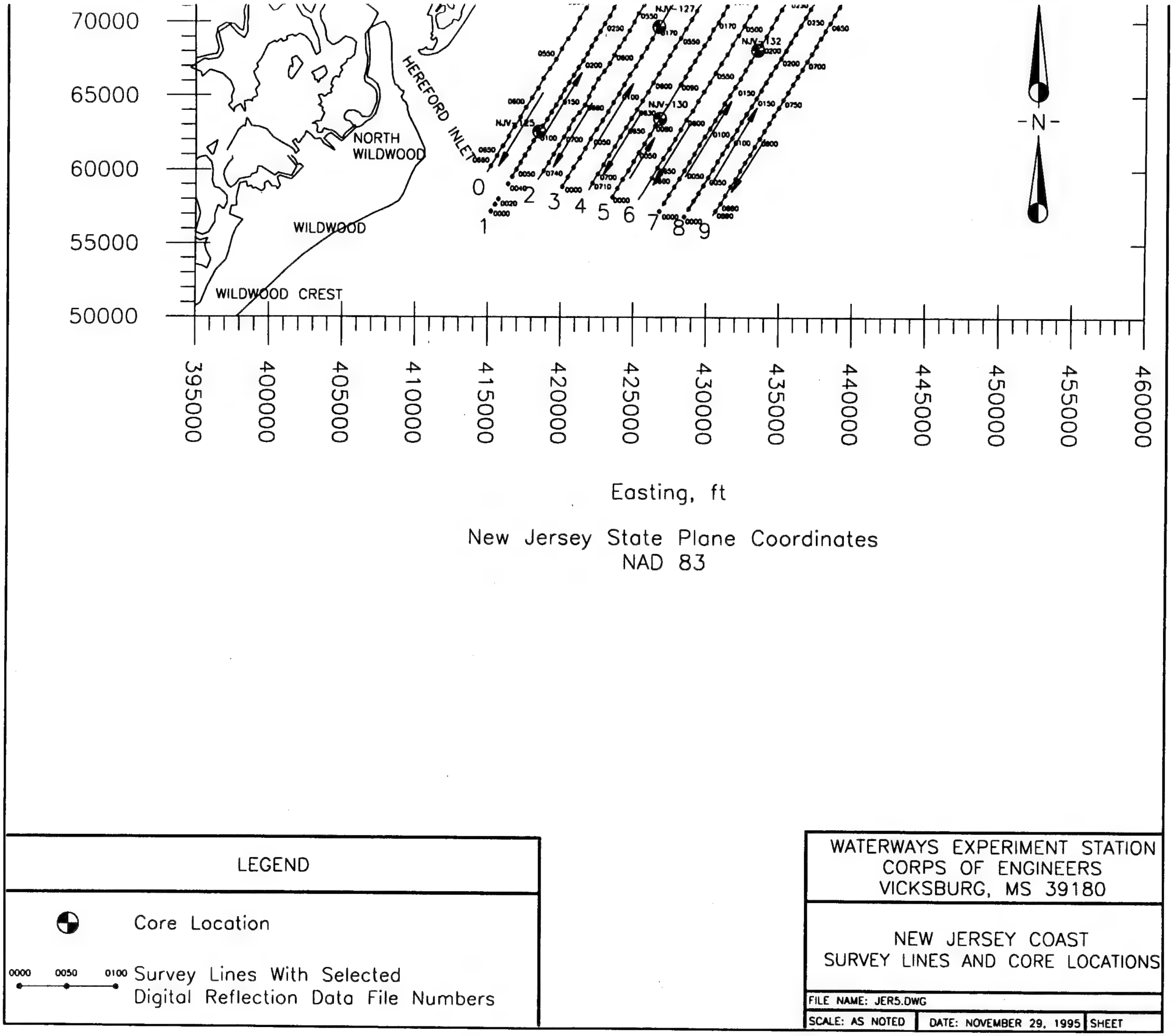


Figure 5. Survey lines and core locations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WILDWOOD CREST
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NJV-127
NJV-130
NJV-132
0 1 2 3 4 5 6 7 8 9
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NAD 83
LEGEND
Core Location
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Survey Lines With Selected
Digital Reflection Data File Numbers
WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180
NEW JERSEY COAST
SURVEY LINES AND CORE LOCATIONS
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SCALE: AS NOTED
DATE: NOVEMBER 29, 1995
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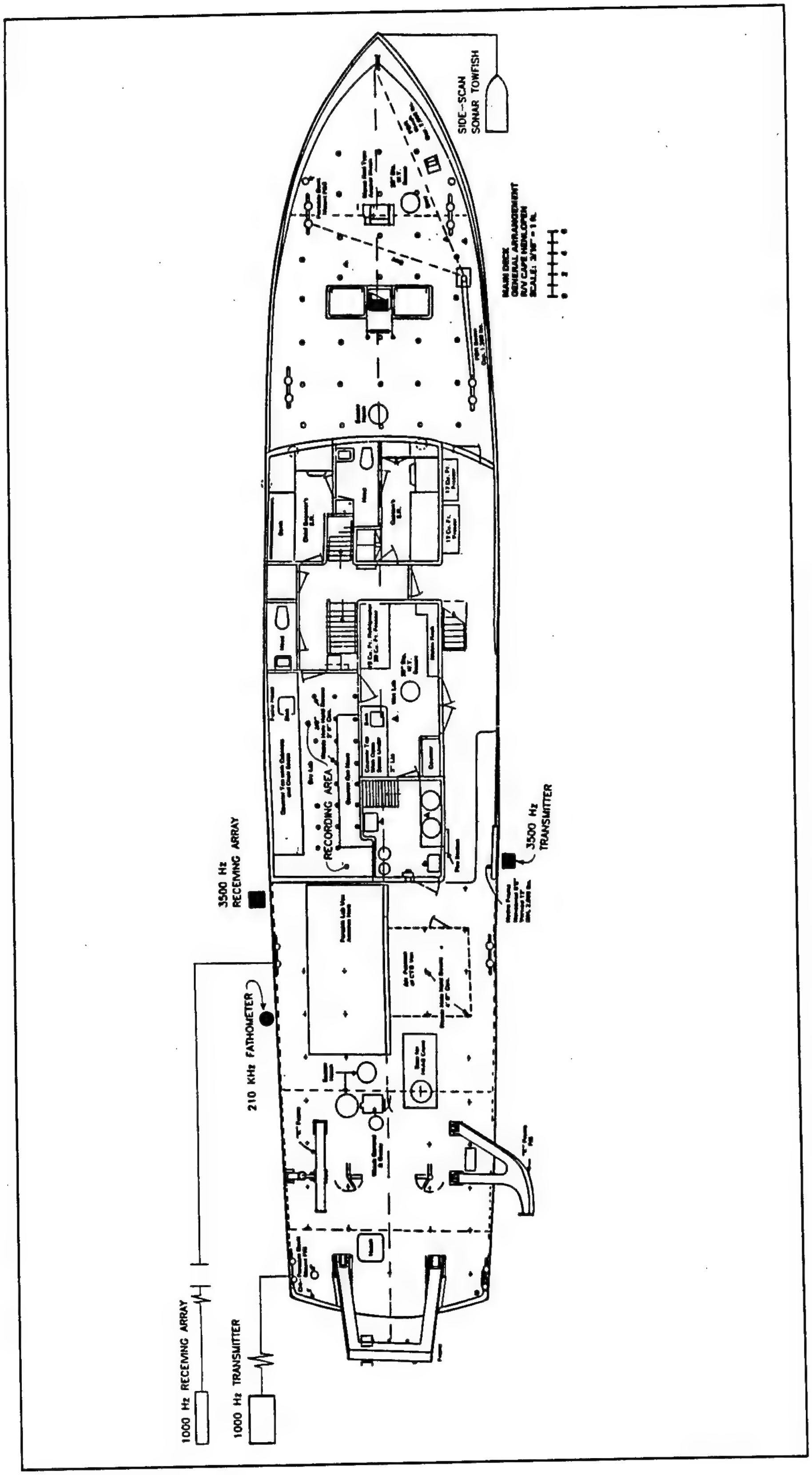


Figure 6. Survey vessel and instrumentation arrangement

The relatively long 1-msec pulse length was chosen in the field during mobilization due to the rough seas and the fact that the survey was being conducted with waves and swell addressing the vessel broadside. This resulted in significant boat roll, and the longer pulse length provided much improved S/N data over the higher resolution shorter pulse lengths.

These systems were originally designed to operate in water depths greater than about 50 ft, resulting in configurations employing integrated transmit/receive (T/R) networks so that the same transducers could be used as transmitters as well as receivers. The resulting transducer ringing and coupling create coherent noise keyed to the transmitter timing. In shallow water, less than 30 ft, significant S/N problems arise due to the coherent noise from the transmitter interfering with the first return.

To solve this problem, a receiving array was deployed independently of the transmitter as shown in Figure 6. By decoupling the receiving array from the transmitter and physically separating the transducer, all of the near-field transmitter ringing was eliminated from the bottom reflection, regardless of water depth. This is the standard pinger deployment configuration for the AI method.

Boomer system. This system is a high-energy, medium-bandwidth unit providing up to 1,000 J of energy in the 400- to 5,000-Hz-frequency band. The system is designed to provide reasonable vertical resolution combined with greater penetration depths in more competent sediments. Because of the high power involved and because the coherent noise radiates to the receiver as well as to the bottom, a separate towed array is used. This array is normally towed at right angles or directly aft of the source. The exact tow point is determined by the water depth and by minimizing the coherent noise to the receiver. Figure 6 presents the boomer configuration used for the New Jersey coast survey.

Side-scan sonar. A dual-frequency side-scan sonar (SSS) was operated throughout the survey to provide increased areal bottom coverage. The SSS was operated at 100 kHz and was towed off the bow as shown in Figure 6.

4 Data Processing and Mapping

Acoustic Reflection Data Records

Continuous subbottom profiles of the acoustic reflection amplitudes obtained using the 3.5-kHz pinger system and the boomer system for surveys performed off the Delaware coast were delivered to the Philadelphia District Project Engineer. The digital data are archived at WES. The records are annotated with digital file numbers, relative depth scales, and all core locations. Figure 7 is a typical color subbottom amplitude record from the Delaware coast survey. The color code represents relative reflection amplitudes as displayed by the legend on the figure. The vertical lines along the top portion of the record are the beginning of individual digital data files, recorded continuously during the survey. Files are sorted into six subfiles (0-5) with each subfile containing bins of forty consecutive soundings. These file numbers are used on the final sediment profiles to correlate the calculations with the raw data. Note the top of the graph is not necessarily the water surface, but an assigned water column offset. This offset allows full vertical expansion of the subbottom display, which in this case extends into the subbottom more than 50 ft. Changes in stratigraphy are readily apparent.

Bathymetry

The acoustic reflection data were combined with the position data and the high-frequency bathymetric data to provide accurate determination of both the horizontal and vertical datums. Bottom depths for the subbottom profiles were adjusted to the tide-corrected fathometer depth measurements since the data provide nearly a 10:1 improvement in resolution over any of the subbottom equipment.

Figure 8 presents the bathymetric map from data measured with the fathometer. The most prominent feature is a linear shoal oriented parallel to the coastline along the central portion of the survey area. The crest of the shoal reaches el -26 along line NJ07, providing a shoal sediment thickness at the crest in excess of 20 ft. Bottom elevations surrounding the shoal extend to

between -45 and -50. Along survey line NJ00, bottom elevations are shown to rise above -40 creating an apparent longitudinal trough running west of the shoal.

It should be noted that depth elevations reported in the core logs differed from the bathymetric elevations at several of the core locations throughout the study area (refer to Table 1 for a comparison of elevations). These discrepancies are unexplained at this time. A review of the tide and depth data collected during the survey uncovered no apparent errors in either the raw data or the processed results. Also, this survey was conducted during the same cruise as the Delaware coast survey, where core and survey elevations exhibited excellent correlation. The coring programs for the Delaware and New Jersey studies were accomplished under separate mobilizations. It is speculated that the discrepancies herein are related to possible differences in the tide data. An independent survey should be conducted to clarify these discrepancies.

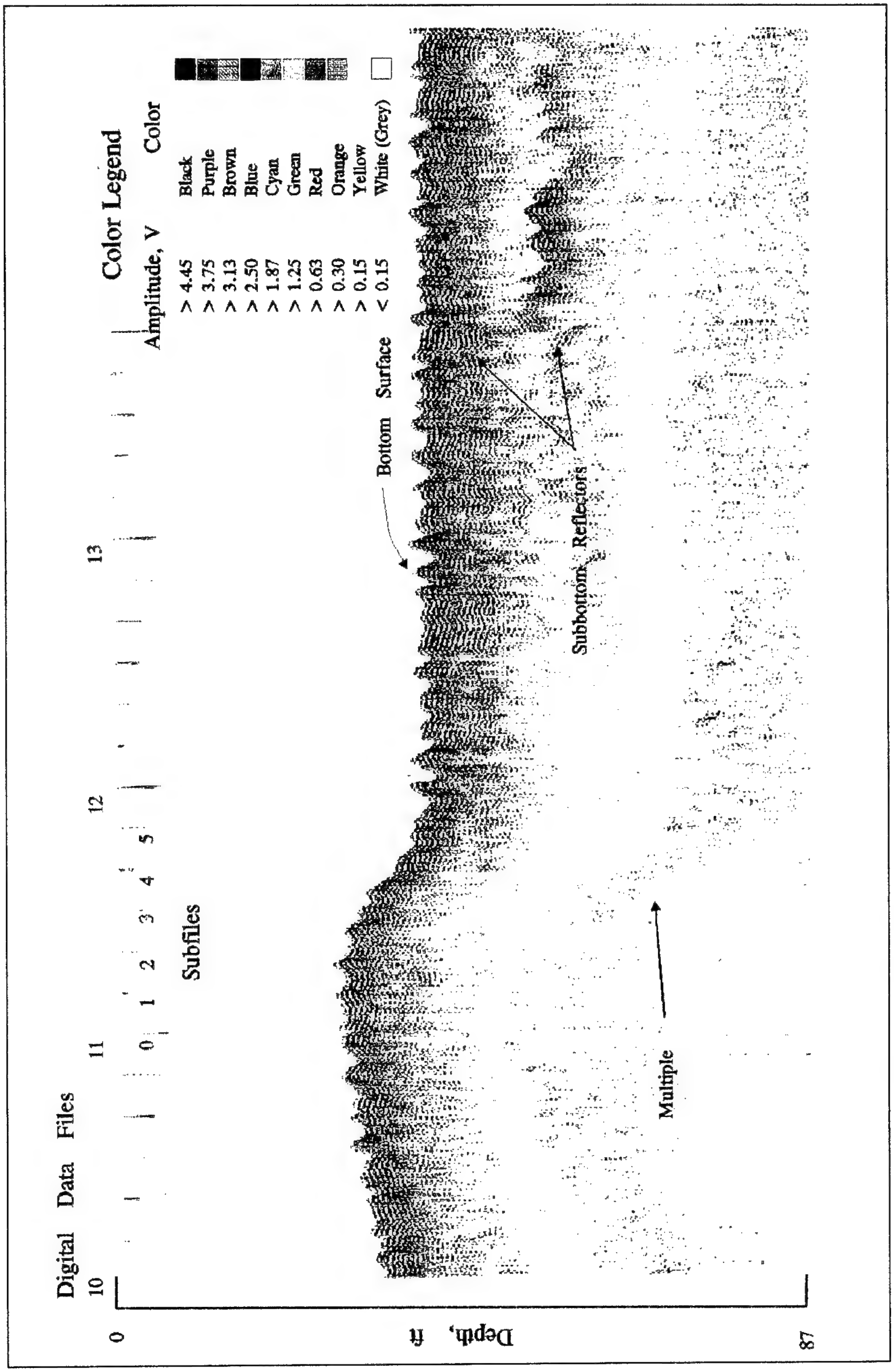


Figure 7. Typical color subbottom amplitude record

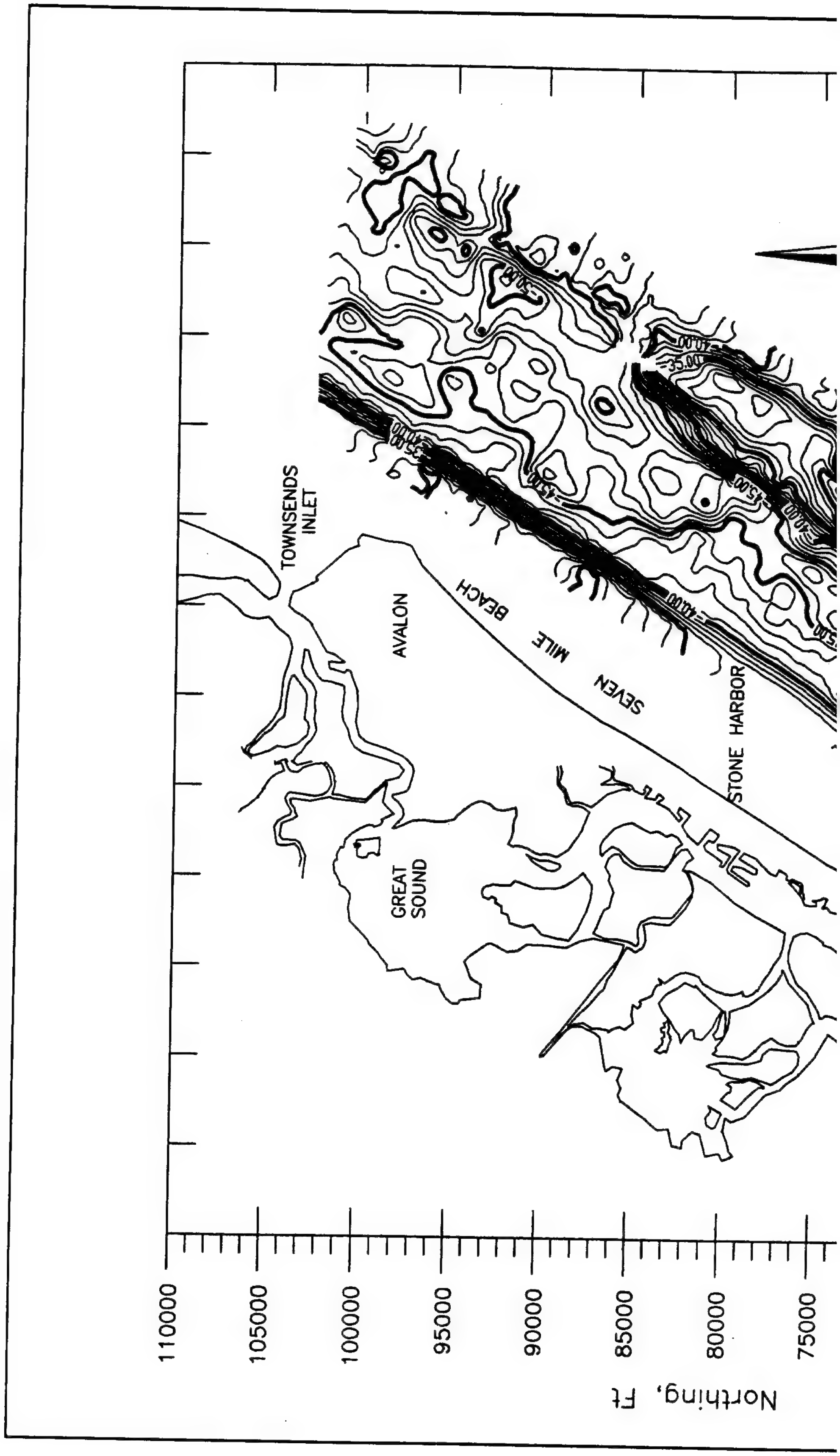
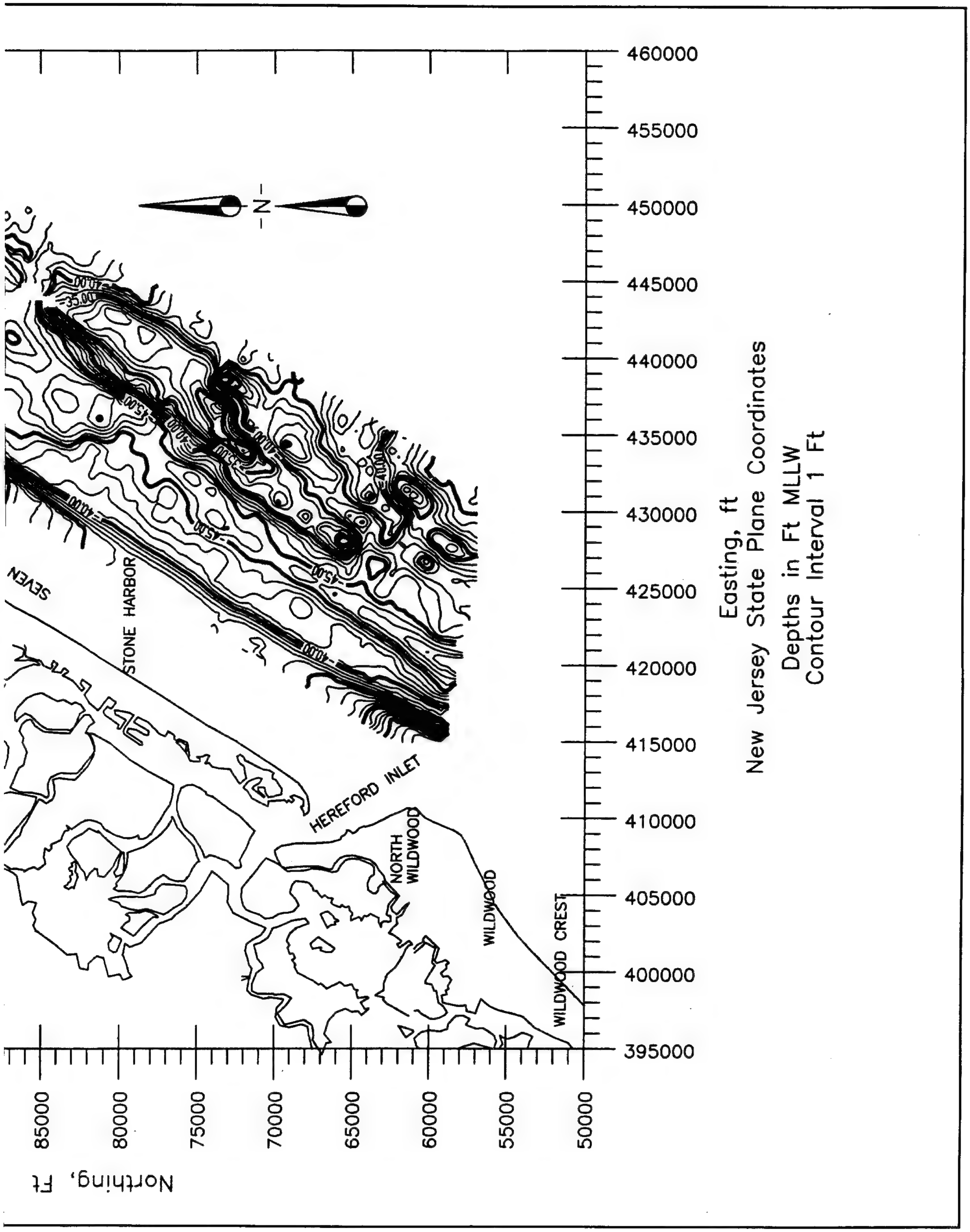


Figure 8. Contour map of New Jersey Coast bathymetry



Easting, ft
New Jersey State Plane Coordinates
Depths in Ft MLLW
Contour Interval 1 Ft
Northing, Ft
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435000
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425000
420000
415000
410000
405000
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395000
85000
80000
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70000
65000
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50000
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SEVEN
STONE HARBOR
HEREFORD INLET
NORTH WILDWOOD
WILDWOOD
WILDWOOD CREST

5 Physical Sediment Analysis

Core data required to calibrate the acoustic response characteristics and to assess the engineering properties of the sediments were provided by vibracore samples retrieved based on guidance from this seismic survey. Figure 5 presents all core locations used for the analysis. The cores are located on the sediment profile maps and the core lithology presented according to the Unified Soil Classification System (USCS). Table 1 lists all cores providing the core name, position coordinates, date collected, and the elevations at each location measured during the vibracoring operation and the seismic survey. There are significant discrepancies between the water depths at some of the cores as shown in Table 1 (refer also to sediment profiles in Plates 1-10). Based on the available information, it was not possible to determine the reason for these discrepancies. As stated previously, survey conditions were identical to the Delaware coast study where there was no tangible difference between the reported core elevations and the seismic survey depth elevations. It is recommended that these discrepancies be investigated and rectified.

Core locations for this study (Cores NJV-123 through NJV-134) were determined after analysis of pinger grey-scale analog reflection records and SSS records, which were obtained during the survey. Locations were selected based upon one or more of the following criteria:

a. Observance of a large area of similar material signatures.

b. Observance of a change of material signature between two significant areas.

c. Convergence of distinct subbottom layers at or near the bottom surface.

d. Anomalous areas of bottom or subbottom signature.

e. Specific seismic equipment calibration sites.

Vibracore samples were collected by Alpine Ocean Seismic Survey, Inc., under contract to the Philadelphia District. Twelve vibracore samples were collected during October 1993 to depths of 20 ft below the mudline. Core positioning was determined using DGPS. All core analysis was performed by the Division Laboratory, U.S. Army Engineer Division, South Atlantic. A

final report of the vibracore sampling collection and geotechnical testing was delivered to the Philadelphia District in May 1994, and then subsequently sent to WES.

Overview of Sediments

The laboratory logs and sediment gradation curves for cores NJV-123 through NJV-134 are provided in Appendix A. The geotechnical testing of selected sections of each core included sieve analysis down to the No. 200 sieve and hydrometer analysis for the fine-grained materials, determination of specific gravity and percent moisture, penetrometer analysis, and classification of sediment samples according to the USCS. Wet and dry densities of selected samples were determined and the entire core sample photographed. Further analysis of the data was conducted by WES to characterize the sediments in a manner suitable for correlation with acoustic data. This included conversion of grain sizes to the ϕ-scale and reclassification of the sediments in both the Wentworth and Shepard classification systems. Mean grain size was computed as the average of the D_{84}, D_{50}, and D_{16} sizes. Table 2 presents an overview of specific engineering properties of each sediment sample collected.

The core sample locations were selected to identify all unique sediment structures based on variations in the seismic reflection data, resulting in sediment samples for nearly the entire range of sediment types underlying the survey area. The core samples were composed mainly of marine sands, with gradations ranging from poorly graded fine-coarse sands (SP) to silty and clayey sands (SM-SC). Nearest the shoreline (cores NJV-123 through NJV-130), the samples taken from the surface sediments were basically silty sands with the fine portion generally less than 20 percent of total sample weight. Further from shore the sampled surface sediments revealed mostly poorly graded sands with little fine material. Core NJV-129 contained 20 percent gravel sizes in the surface sample, and NJV-131 contained nearly 35 percent gravel.

Below the surface, especially in areas where stratigraphic changes are apparent on the acoustic records, the sediment samples contained high percentages of silts and clays (CL and ML classifications). These materials are found in all cores except NJV-129 and -131 with thicknesses varying from 2 ft to 15 ft. The deepest samples from the cores were generally composed of poorly graded sands with gravels.

Correlation of Sediment Properties

To predict soil type, density, and mean grain size through acoustic impedance algorithms, it is essential that the intercorrelation of these sediment properties be assessed for a particular sediment environment. An empirical relationship between density and mean grain size was developed and reported

for the Delaware coast geoacoustic study as shown by the dashed line in Figure 9. As discussed in McGee (1995), this derivation was accomplished without measured density values from the sample data; instead, it was based on measured properties from several geoacoustic databases. Data compiled by Hamilton and Bachman (1982) from the continental shelf and slope are presented in the figure to illustrate mineralogical differences that can exist between different sediment environments. Hamilton and Bachman's curve is obviously offset from the empirical data generated by McGee (1995). These differences are caused by a number of interrelated factors such as grain size, uniformity of grain size, grain shape, packing of grains, and mineralogy (Hamilton and Bachman 1982). Using the empirical relationship for density and mean grain size for the Delaware coast, an impedance versus density relationship was inferred using acoustically derived impedances as shown in Figure 10, providing density estimates within ± 10 percent. Impedance versus mean grain size was established from direct comparisons of acoustically derived impedance and sample gradation analysis as presented also in Figure 10 and provided mean grain size estimates assumed to fall within $\pm 0.5\phi$.

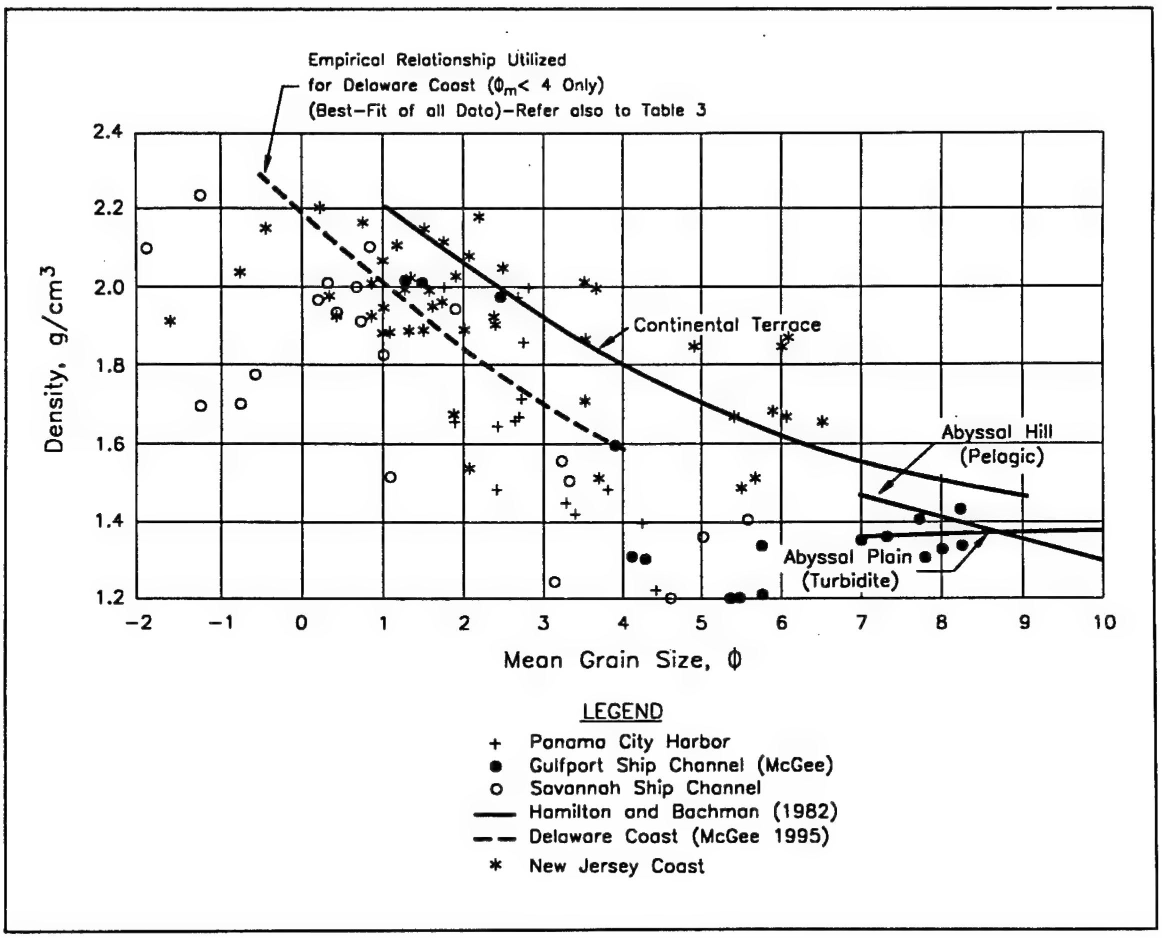
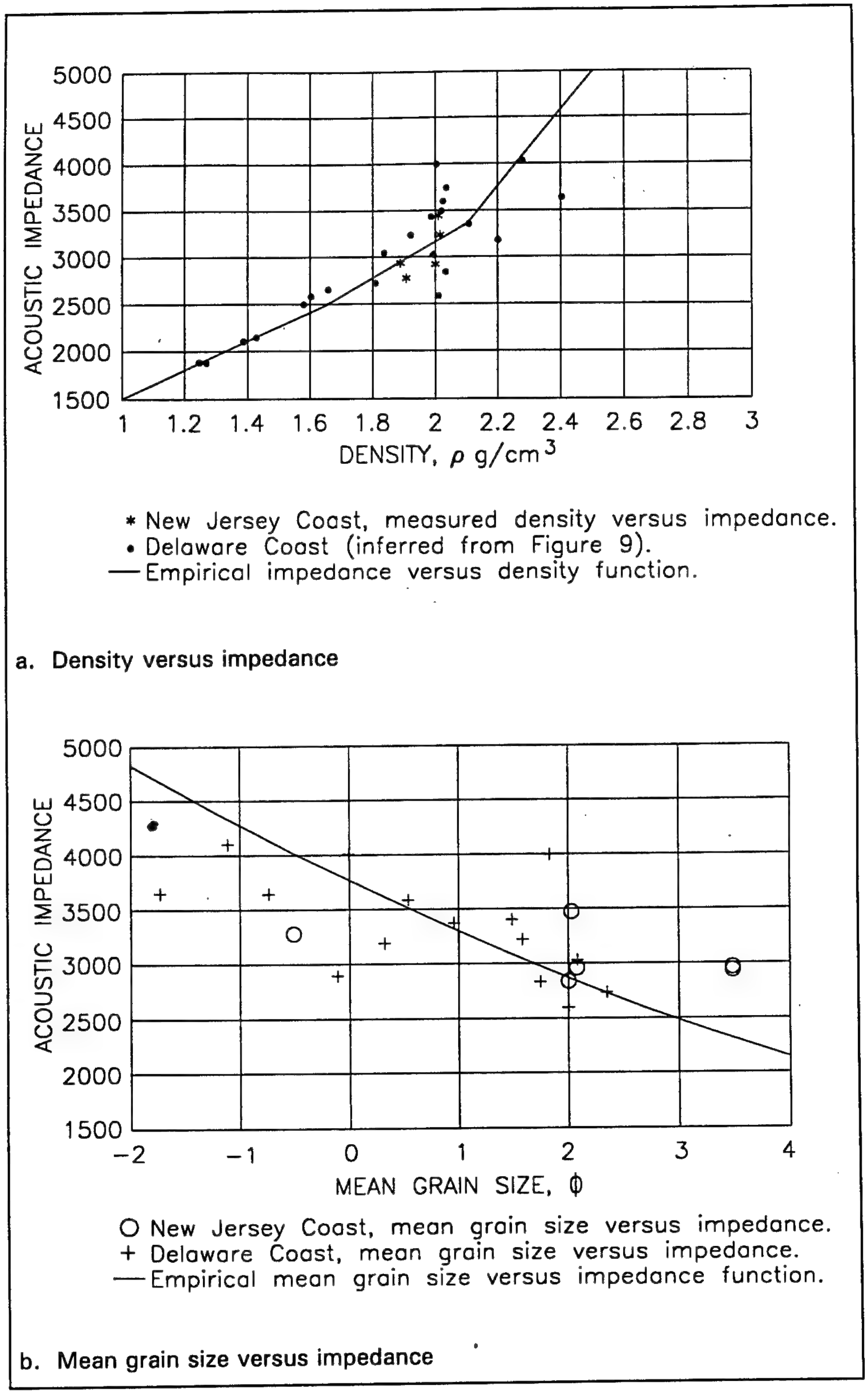


Figure 9. Empirical derivation of mean grain size versus density



a. Density versus impedance

b. Mean grain size versus impedance

Figure 10. Density versus impedance, Delaware coast (McGee 1995)

For the New Jersey coast study, sufficient sample analysis was performed to directly relate acoustic impedance with density and mean grain size. Density versus mean grain size for the New Jersey coast vibracore samples has been included in Figures 9 and 10, which confirm the reasonableness of the Delaware coast derivation. As shown by Figure 9, more than 80 percent of the data points fall within the 0 to 3ϕ ranges. On average, for a given density within this range, the ϕ size varies approximately $\pm 0.7\phi$. For grain sizes smaller than 4ϕ, the associated density values are consistently higher than for samples retrieved from previous sites (refer to Panama City Harbor, Gulfport Ship Channel, and Savannah Ship Channel data points in Figure 9). This is most likely due to an increased percentage of coarse-grained sediments within the samples compared with these other sites. For sediments coarser than 0ϕ, associated densities are consistent with the previous data and reflect a decrease in the rate of density change relative to increasing grain size. In general, between 0 and 4ϕ for the data presented, the density increases proportionately with increasing grain size. For grain sizes larger than 0ϕ (coarse sands and gravels) and smaller than 4ϕ (predominately silts and clays) the rate of density change is less.

The New Jersey coast sediment characterization used to relate density, mean grain size, and soil type is summarized in Table 3 and is based in large part on the density-mean grain size correlations form both the Delaware and New Jersey sites. In general, the categories established delineate the predominantly clay, silt, and sand sediment types. However, as previously shown, sediment mixtures, such as clayey sands and silty sands, can exhibit uncharacteristically high or low density values. Also, the mean grain size parameter may not always completely describe actual sediment conditions. Factors such as sorting and grain size variability are not necessarily reflected in the mean grain size parameter. The present state of geoacoustic technology really does not allow for the micro-delineation of all grain size parameters. It does, as will be shown, provide good characterization of the general nature of the insonified sediment structure.

6 Geoacoustic Modelling

Using calibration procedures for data with high S/N ratios, seismic reflection data are processed to provide estimates of the density, mean grain size, and soil type of bottom and subbottom natural marine sediments. Calibrations are performed by correlating acoustic impedance values calculated from the seismic reflection data at a sample location with the measured information (density, mean grain size, etc.) at that location. Experience to date has shown that calibrations made at a few locations within a geologic region can provide the necessary shallow seismic parameters to accurately calibrate and describe an entire region (McGee[1] and McGee, Ballard, and Caulfield 1995). Calibration of the acoustic reflection data for the New Jersey coast survey is briefly described in the following paragraphs. Since the data acquisition was accomplished during the same field mobilization as the Delaware coast survey, it would seem logical that the equipment calibration parameters would be the same. However, as will be shown in this chapter, there was a 1- to 2-db difference between the Source Levels *SL* for the 3.5-kHz system derived from the New Jersey data and the Delaware data.

Equipment Calibration: Sources and Receivers

Sonar equations

The geoacoustic parameter calibration procedure begins by determining the total acoustic energy incident at the bottom surface. This basically involves determining the precise reflection coefficient for the first reflector (bottom surface) and its associated acoustic bottom loss for a given sediment. Since the sound velocity of water and its density can be readily measured, the absolute acoustic impedance of the water can be calculated. Knowledge of the reflection coefficient, which by the way is completely independent of frequency, from the water-bottom interface allows direct computation of the absolute acoustic impedance of the first layer of the bottom. The total energy produced by the source, or source wavelet, must be known absolutely. This

[1] R. G. McGee. (1991). "Subbottom hydro-acoustic survey of Gulfport Ship Channel," Memorandum for Record, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

is accomplished through use of a calibration hydrophone allowing determination of SL and the transmission losses associated with underwater acoustic wave propagation through the *sonar equations*. The sonar equations, discussed thoroughly by Urick (1983), describe the quantitative effects on sonar equipment created by the many phenomena peculiar to underwater sound production. These equations are both design and prediction tools for underwater sound applications and relate the effects of the medium, the target, and the equipment. The general sonar equation is given as follows:

$$S_R = SL - N_w - N_{hyd} + N_A + DI + BL \tag{4}$$

where

S_R = bottom reflection energy at receiver, db

SL = total energy of source, db

N_w = transmission loss due to spherical spreading along the path of propagation, 20 x Log_{10} (range, m), db

N_{hyd} = receiver sensitivity, db

N_A = amplifier gain, db

DI = directivity index of receiving array, db (function of transducer beam pattern)

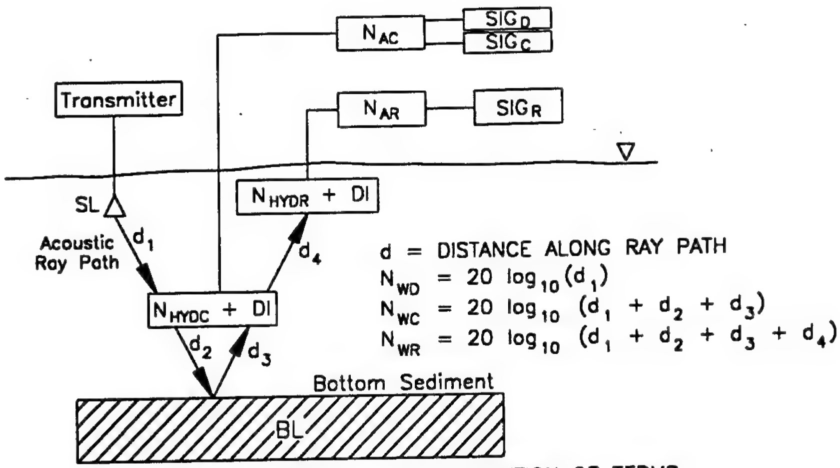
BL = bottom loss, db = 20 $\log_{10}(R)$

R = reflection coefficient

Figure 11 is a detailed depiction of the physical elements in a normal calibration and bottom reflection sonar equation solution case. The N_A value includes all preamplifiers and amplifiers and is obtained from the electrical calibration of the receiving equipment. The calibration hydrophone receive sensitivity N_{hydc} is available from manufacturers of the hydrophone and should be traced to ANSI Standard S1.20-1988 (Acoustical Society of America 1988). The receiving array sensitivity N_{hydr} may also be available from the manufacturer or can be easily calibrated in the field using the calibration hydrophone and an alternate form of the sonar equation. This procedure will be discussed in detail a little later in the report.

Directivity index

The DI is a function of the beam pattern of the transducer array and is an indication of the amount of the total signal the hydrophone is permitted by its



NOTE: REFER TO EQUATION 4 FOR DEFINITION OF TERMS

SONAR EQUATIONS:

$$SIG_R = SL - N_{WR} - N_{HYDR} + N_{AR} + DI + BL$$
$$SIG_C = SL - N_{WC} - N_{HYDC} + N_{AC} + DI + BL$$
$$SIG_D = SL - N_{WD} - N_{HYDC} + N_{AC}$$

Where:

SIG_R = BOTTOM REFLECTION SIGNAL FROM RECEIVER ARRAY
SIG_C = BOTTOM REFLECTION SIGNAL FROM CALIBRATION HYDROPHONE
SIG_D = DIRECT WAVE SIGNAL FROM CALIBRATION HYDROPHONE
N_{AC} = AMPLIFIER GAIN FROM CALIBRATION HYDROPHONE
N_{AR} = AMPLIFIER GAIN FROM RECEIVER ARRAY

Figure 11. Elements in acoustic calibration and bottom reflection sonar

sensitivity pattern. The higher the *DI*, the more discriminating the hydrophone is against signals arriving from directions other than along the acoustic axis. Figure 12a presents the directional pattern of the MASSA Model TR75-A transducer used with the pinger system. Because the transmitter and receivers are horizontally offset, as explained in Chapter 3, the *DI* becomes a significant parameter due to the reflection angles along the path of propagation. Figure 12b presents the equipment geometry for the Delaware and New Jersey coast surveys and its effect on directivity. Figure 12c is the *DI* correction versus water depth for application in the sonar equation.

Source level calibration

The first step in the calibration process is to determine the absolute *SL*. These data are available from the manufacturers of some sonars. Unfortunately, many seismic systems do not have this information readily available, and even if they did, the field operating conditions vary to such an extent that the published levels are not sufficient for precise reflection computations.

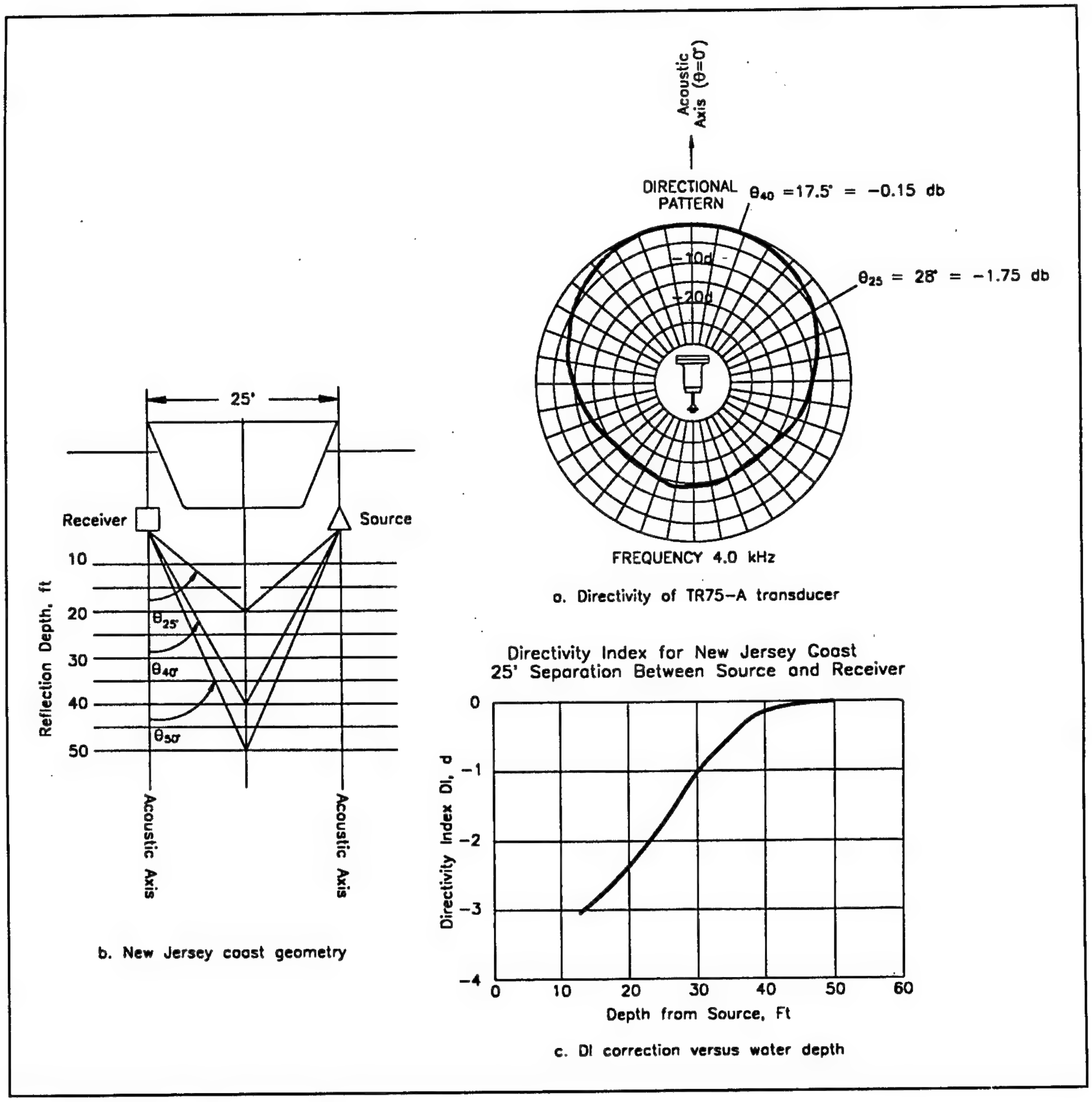


Figure 12. Computation of *DI* versus water depth and transducer separation

The direct wave calibration of the sonar *SL* is accomplished by writing the sonar equation for the measurement of the direct wave via the calibration hydrophone as follows:

$$S_D = SL - N_{wdir} - N_{hydc} + N_A \tag{5}$$

where

S_D = direct wave signal level, db

N_{wdir} = transmission loss between source and calibration hydrophone, db

All the terms in Equation 5, except *SL*, are either absolutely known or directly measured. Therefore, solving for *SL*, the absolute SL is determined. Figure 13 presents a typical seismic system calibration data plot. This single data record contains all the field data required to completely calibrate all aspects of the equipment operations and provide calibration data for the surface sediment impedance. The SL calibration is performed using the data between files 0002 and 0004 where variations in amplifier gain and hydrophone range are occurring. As reported for the Delaware coast (McGee 1995), the measured RMS SL for the 3.5-kHz pinger system operating at approximately 5 kW of power was between 99 and 100 db. Field operating conditions, i.e., high sea state and calibration hydrophone deployment, during the Delaware coast survey required a nonstandard methodology for assessing SL; specifically, using estimated sediment properties from local core data, the acoustic data were manipulated through the sonar equation to arrive at an SL value that would result in the equivalent acoustically derived sediment properties, mainly density. Since densities were inferred from the correlations of sediment properties (Figure 9) rather than from direct measurements, the actual SL may be in error by ± 1 db. Also, survey conditions such as 2- to 3-ft seas may have possibly contributed to signal degradation resulting in a discrepancy in the SL determination compared with the New Jersey survey data.

Since wet density analysis was performed on selected surface samples for the New Jersey coast, acoustic impedance and density were directly correlated. This was carried out through rearranging the sonar equation to solve *SL* as a function of *BL* as follows:

$$SL = S_R + N_{hyd} - BL + N_w - N_A - DI \tag{6}$$

where $BL = 20 \log_{10} (R)$ and *R* is related to impedance according to Equation 2. Using established impedance versus density relationships as shown in Figure 14, the appropriate *SL* was determined using Equation 6 by replacing the *BL* term with predicted *BL* estimates from these databases. Table 4 presents a summary of acoustic measurements and surface sediment properties for selected core locations throughout the New Jersey study area using an RMS SL of 102 db relative to 1 dyne/cm^2. Figure 15 presents acoustically derived density versus laboratory-measured densities of selected surface samples and shows that using an SL of 102 db results in density estimates within ± 2.5 percent or ± 0.05 g/cm^3. This is a 2-db difference in SL from the Delaware coast survey (McGee 1995) even though the 3.5-kHz system was operated in the same way. The difference is attributed mainly to calm sea conditions during the New Jersey survey resulting in less signal degradation and improved S/N data. Also, the SL was based on correlation with actual

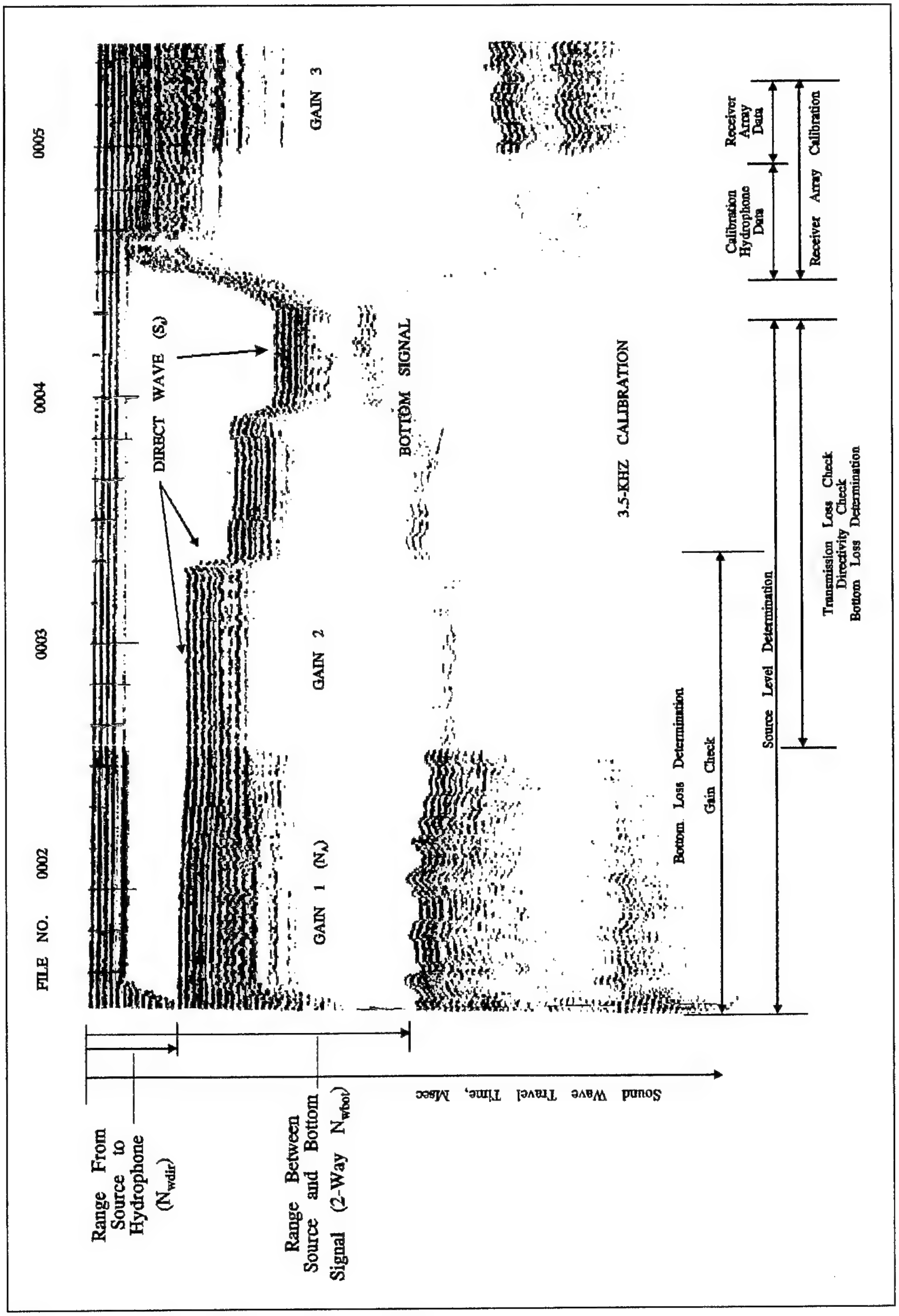
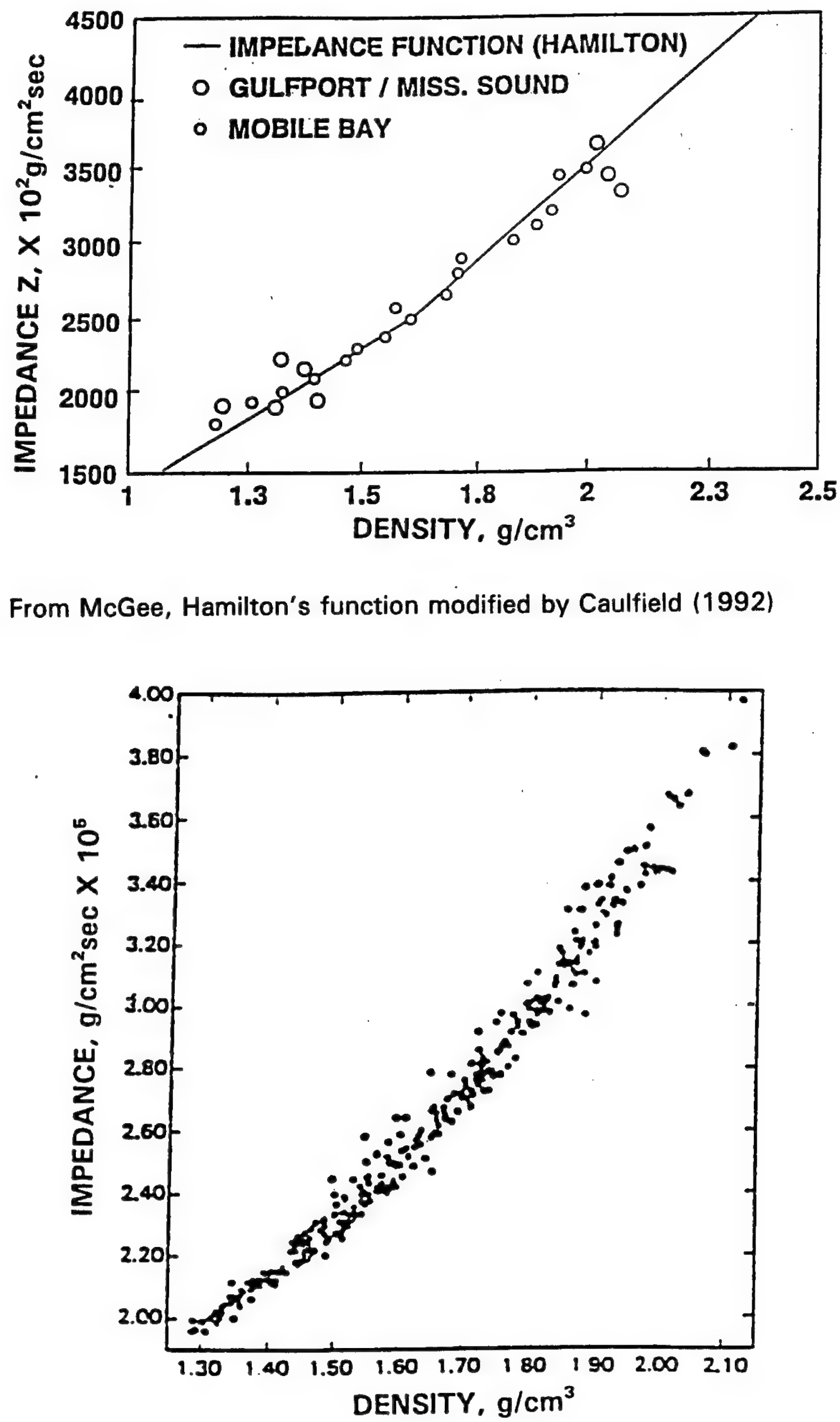


Figure 13. Typical acoustic calibration record



a. From McGee, Hamilton's function modified by Caulfield (1992)

b. From Hamilton and Bachman (1982)

Figure 14. Density versus impedance: General

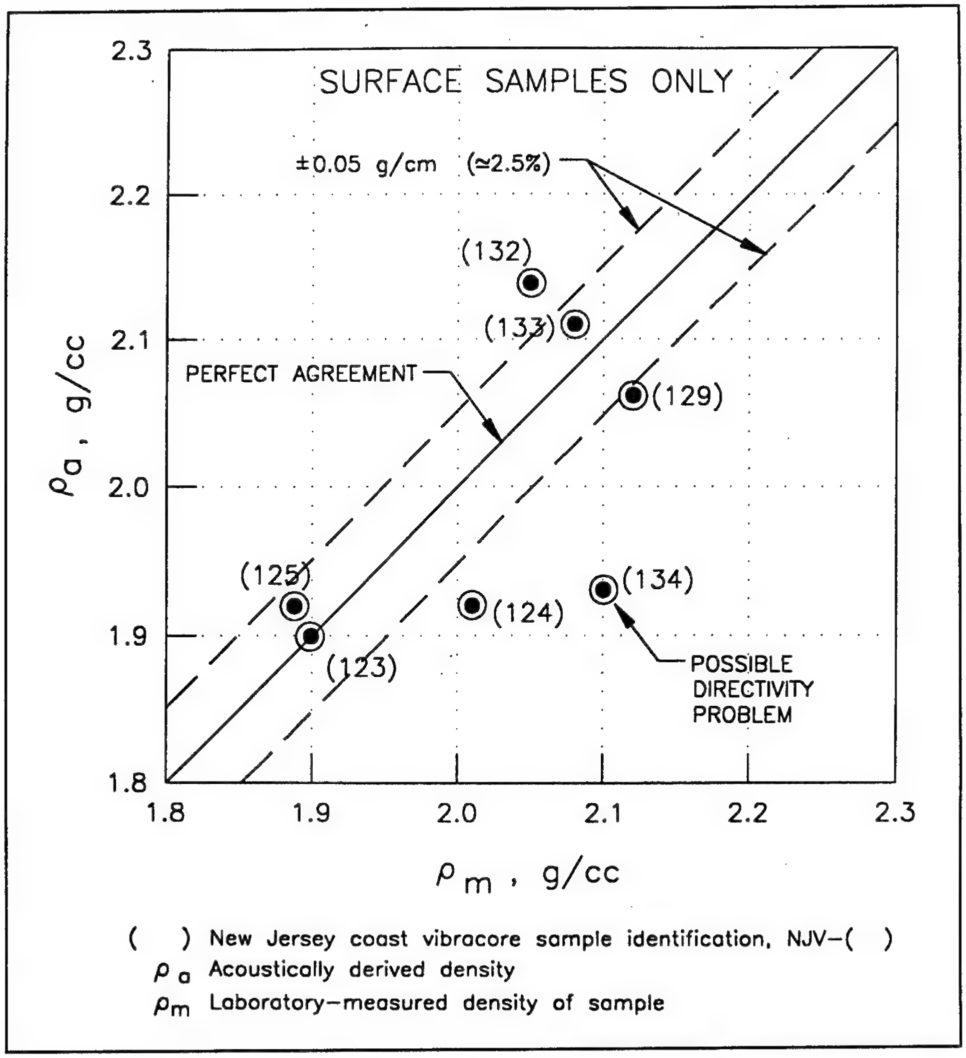


Figure 15. Acoustically derived density versus laboratory sample density for New Jersey coast surface samples

sediment densities rather than densities inferred from density-grain size relationships.

Receiving hydrophone sensitivity calibration

As with the SL, the array sensitivity of the receiving hydrophones N_{hydr} must be absolutely known. The field calibration is performed by comparing the signal levels of the receiving array with the calibration hydrophone over the same bottom condition. The calibration hydrophone is located in the immediate vicinity of the receiving array at the same depth elevation. The sonar equation is designed to solve for N_{hydr} as follows:

$$N_{hydr} = N_{hydc} + S_{Rr} - S_{Rc} - N_{Ar} + N_{Ac} \tag{7}$$

where S_{Rr}, N_{Ar}, and S_{Rc}, N_{Ac} are the receive signals and amplifier gains for the receiving array and calibration hydrophone, respectively. The N_{hydr} for the array used for the New Jersey and Delaware coast surveys has been calculated and verified over numerous projects to be -72 db relative to 1 dyne/cm^2.

Determination of Bottom Loss and Surface Reflection Coefficient

The bottom surface characteristics are evaluated through the sonar equation by rearranging Equation 4 to solve for *BL* as follows:

$$BL = S_R + N_{hyd} - SL + N_w - N_A - DI \tag{8}$$

Since all terms on the right side of the equation are now known, *BL* and therefore the surface reflection coefficient ($BL = 20 \log_{10} R$) and acoustic impedance can be readily determined. If the desired result is an assessment of the bottom surface characteristics, the acoustic solution is complete. All that remains is the correlation of the acoustic parameters with the physical sediment properties. *BL* was evaluated over the entire study area and is plotted, along with the associated density predictions, across the top of the sediment profiles in Plates 1-10. This presentation provides an indication of the lateral variability in the sediment properties of the surface materials within hatched sediment units. Several examples for selected segments of the survey will be presented throughout the report.

Geoacoustic Relationships

Impedance versus density model

Using impedance versus density relationships from Hamilton and Bachman (1982) and McGee[1] (Figure 14) incorporated with the laboratory-determined densities from the New Jersey coast samples, an impedance versus density model was developed. Figure 16 presents Z versus ρ for the New Jersey study along with the models developed by Hamilton and Bachman, Caulfield,

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[1] R. G. McGee. (1991). "Subbottom hydro-acoustic survey of Gulfport Ship Channel," Memorandum for Record, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

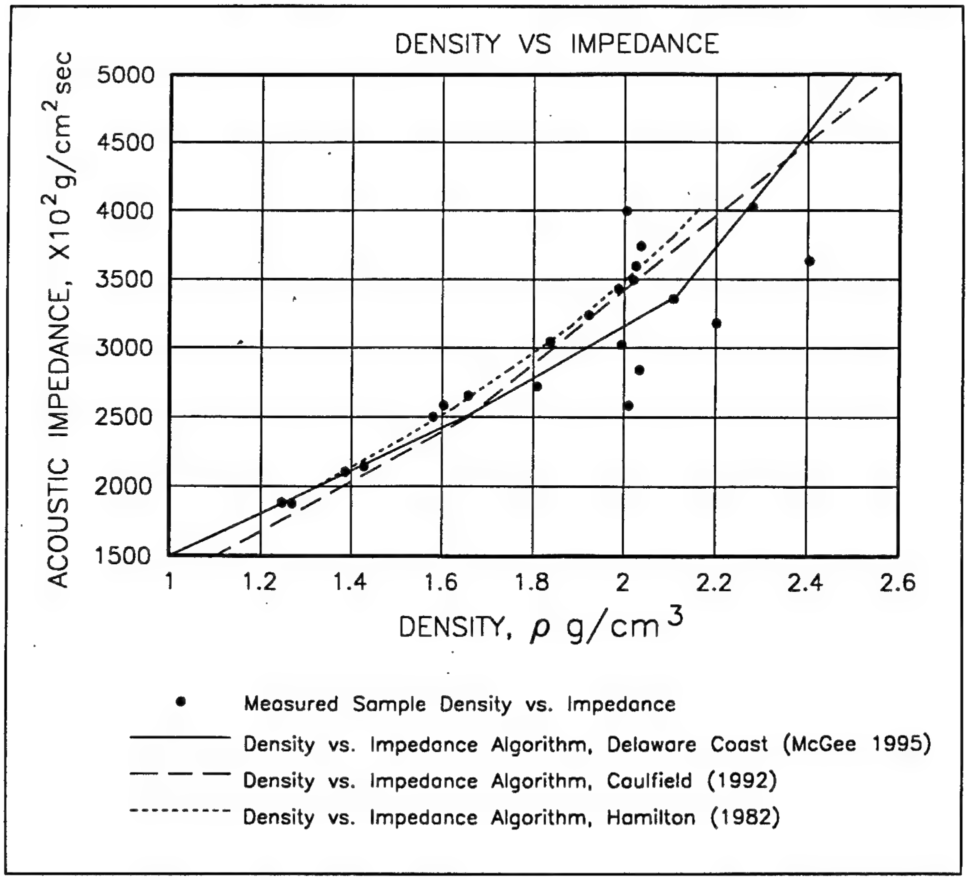


Figure 16. Impedance versus density

and McGee presented in Figure 14. As shown in Figure 15, acoustically derived density estimates using this model for the surface sediments are within ± 2.5 percent or ± 0.05 g/cm^3. Subbottom density estimates are not included in the assessment since the absorption loss, which is an estimate, must be taken into account in determining the acoustic impedance for buried horizons.

Impedance versus mean grain size model

The empirically derived impedance-grain size function for the Delaware coast is used also for the New Jersey coast study presented in Figure 10. Between 0 and 3ϕ acoustic impedance exhibits good correlation with the mean grain size parameter where for any given impedance value the resulting acoustically derived mean grain size ϕ_{mc} is within $\pm 0.5\phi$ of the actual sample size. For grain sizes larger than 0ϕ (coarse sands and gravels and coarser), most of the impedance data points fall below the curve indicating that mean grain size estimates for impedances greater than about $3{,}800 \times 10^2$ g/cm^2 sec may be low. Referring to Figure 10, the model presented is upper bound at an impedance of $4{,}750 \times 10^2$ g/cm^2 sec at -2ϕ. No grain sizes greater than -2ϕ are modelled.

Mean grain size does not always fully describe the actual sediment condition. The presence of different sediment types within a given sediment unit can have a significant effect on the acoustic response characteristics of that sediment unit. Outside the 0 to 3ϕ range many of the samples were not poorly graded (SP). For example, core NJV-129 contained 5 percent fines and 15 percent gravel sizes. Whereas the density estimates for this sample were within 0.06 g/cm^3, the mean grain size prediction was finer by 1.5ϕ. Samples from cores NJV-124 and -125 were classified as silty sands with a mean grain size of 3.47ϕ. Acoustic estimates were coarser by 1.7ϕ, but the density predictions were within 0.02 g/cm^3. These examples are presented to demonstrate the sensitivity of impedance as a function of mean grain size and to warn the user to use the sediment descriptions of mean grain size as a general guide in evaluating the sediments in question. The present state of acoustic technology does not allow for the microdelineation of sediment gradation. Finally, the mean grain size model used here does not apply for sediment sizes smaller than 4ϕ. Sediments in this category are primarily fine materials such as silts and clays.

Example *BL* versus sediment properties

Acoustic *BL* was determined at each core site for Cores NJV-123 through NJV-134. The *Z* for the bottom surface reflection was determined by computing the total wavelet energy in the bottom reflection signal and substituting this energy for S_R into Equation 8, solving for *BL*. *BL* was then converted to reflection coefficient *R* and *Z* using Equation 2. Figures 17 and 18 present typical bottom *Z* evaluations for core sites NJV-123 and NJV-133. The figures contain the pinger reflection record and a plot of the *BL* computations and statistical evaluations versus sequential data files. The mean *BL*, *R*, and *Z* values represent the arithmetic mean of all soundings over the entire record. Individual data points on the plot are the statistical results (mean and $\pm$ standard deviation) for the 40 consecutive soundings stored in each data subfile. This analysis will show the sensitivity of density and mean grain size as a function of impedance and supports the discussions that density is more reliably assessed using acoustic impedance.

The surface sample from Core NJV-123 is characterized according to the USCS on the laboratory logs (Appendix A) as a gray, silty sand with a measured wet density of 1.90 g/cm^3 and a mean grain size of 2.00ϕ. The Shepard classification (Table 2) also describes the sample as a silty sand with a grain size distribution of 65 percent sand, 22 percent silt, and 13 percent clay as shown in Figure 19. In terms of mean grain size, the USCS and Wentworth system classify it as a fine sand. The computed mean *BL* was 10.00 db (Figure 17) with an equivalent *R* of 0.328. The *Z*, computed relative to seawater (Equation 2) is $2{,}876 \times 10^2$ g/cm^2 sec. Using the density model of Figure 16, the acoustically derived density is estimated to be 1.90 g/cm^3, equivalent to the laboratory-measured density. Acoustically derived mean grain size compared within 0.1ϕ of the in situ at 1.90ϕ.

The surface sample from Core NJV-133 is described in the laboratory log (see Appendix A) as a tan, poorly graded sand (SP) with a trace of gravel sizes and shell fragments. The laboratory-measured wet density is 2.08 g/cm^3 and the mean grain size is 2.08ϕ. According to mean grain size, the USCS and Wentworth systems categorically classify the sample as a fine sand. Since 95 percent of the sample is sand, the Shepard classification is simply sand. The computed mean *BL* was 8.25 db (Figure 18) with an equivalent *R* of 0.401. The resultant *Z* for the site is 3,490 $\times$ 10^2 g/cm^2 sec. According to the density model (Figure 16) the acoustically derived density is estimated to be 2.11 g/cm^3, which is within 1.44 percent of the laboratory-measured density. Acoustically derived mean grain size is 1.58ϕ, a difference of 0.52ϕ from the in situ value.

This analysis was accomplished for all surface sampled locations summarized in Table 4. These values are for the surface sediments only and are used to calibrate and verify the impedance/density function used for sediment characterization since the surface *Z* is well-defined. Impedances of the subbottom layers are determined only after all the losses, particularly absorption, have been estimated. Therefore, for development of the impedance function, it was preferred to use only impedance values calculated from absolute acoustic measurements.

Absorption calibration

One of the primary energy losses encountered during acoustic wave propagation through differing media is that due to absorption. This loss involves a process of conversion of acoustic energy into heat and thereby represents a true loss of acoustic energy to the medium in which propagation is taking place. Energy loss due to absorption has been researched extensively for marine sediments through which reasonable approximations of loss are provided. Hamilton and others (refer to Bibliography) present convincing experimental evidence to absorption's relationship to the first power of frequency. Hamilton (1972a) presents the following important observations:

a. Absorption is dependent on the first power of frequency.

b. Velocity dispersion is not important.

c. Intergrain friction appears to be, by far, the dominant cause of wave energy dampening in marine sediments.

Specifically, absorption varies as a function of frequency according to the empirical equation

$$\alpha = kf^n \tag{9}$$

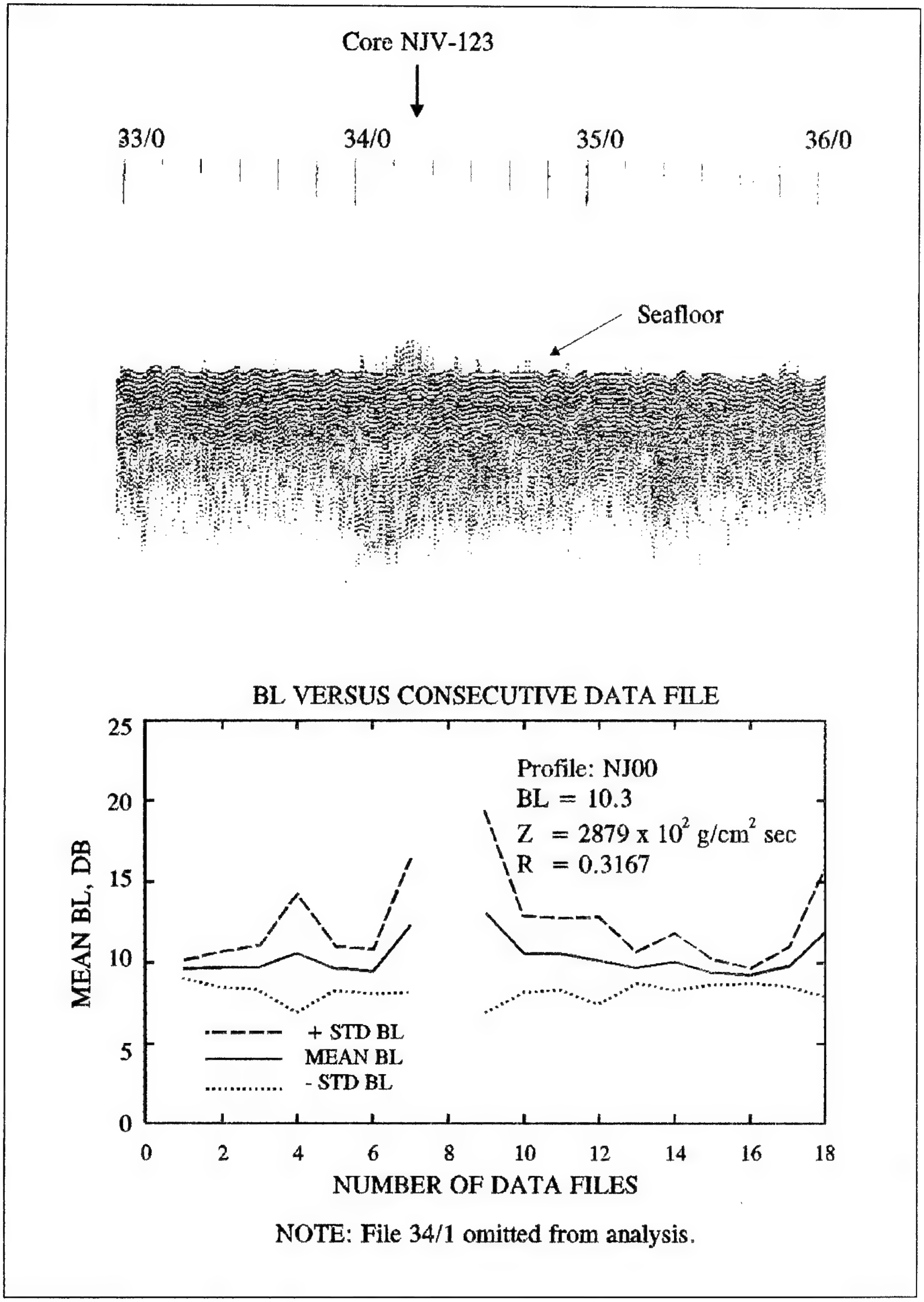


Figure 17. Impedance evaluation, core site NJV-123

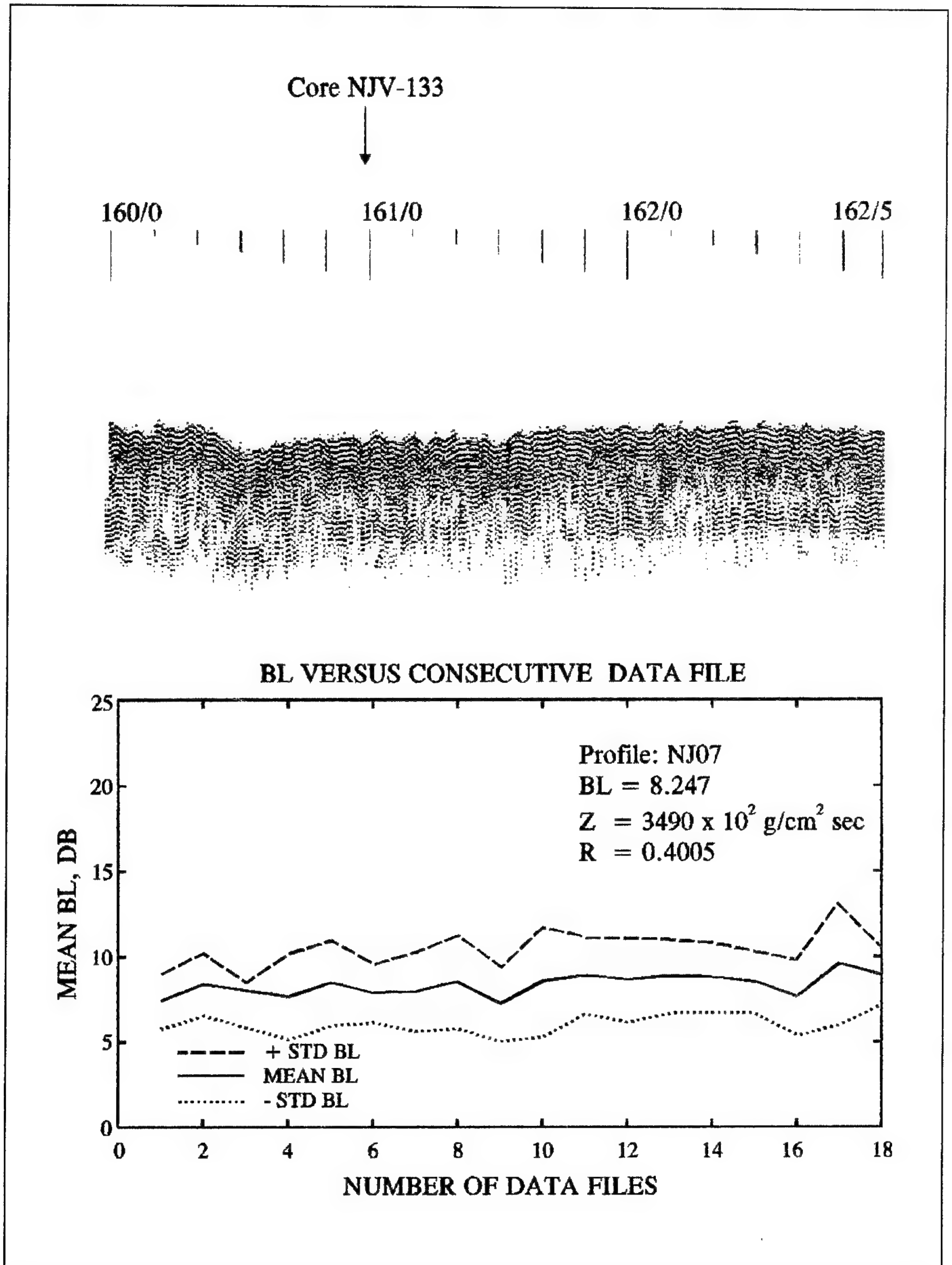


Figure 18. Impedance evaluation, core site NJV-133

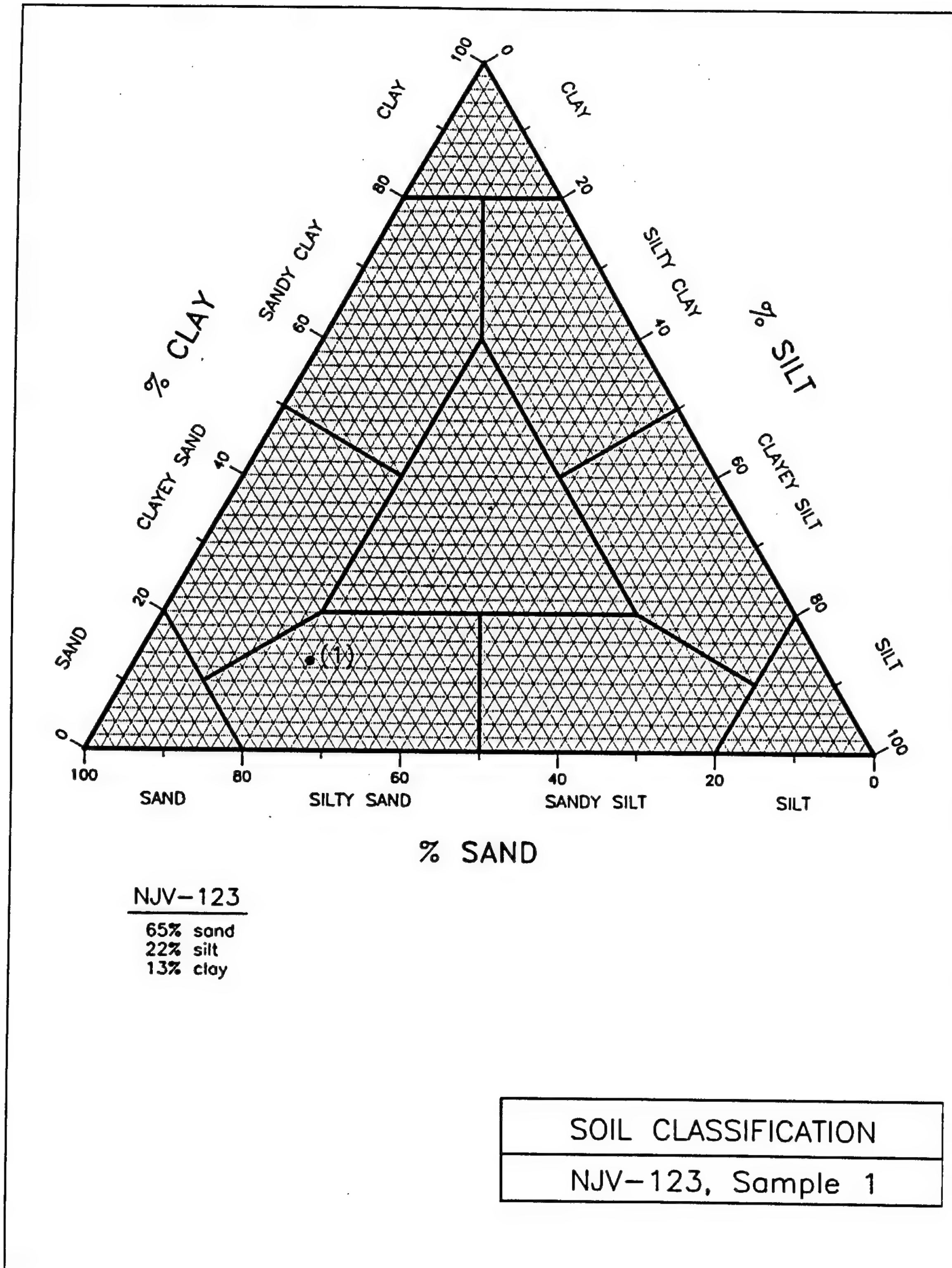


Figure 19. Shepard classification, core NJV-123

where

α = absorption, db/m

f = frequency, kHz

k = attenuation coefficient, db/m/kHz

n = exponent of frequency

The constant n has been experimentally determined to be essentially unity for the frequencies of interest, leaving k in Equation 9 as the only variable. This constant varies with sediment type and is related to porosity and mean grain size as shown in Figure 20. A modification of this model as described by Caulfield and Yim (1983) and Caulfield, Caulfield, and Yim (1985) is used in the AI method to estimate the engineering properties of marine sediments. A reasonable measure of absorption, in keeping with Equation 9, is provided by Caulfield and Yim (1983) assuming an exponential correction as a function of frequency by

$$\alpha = 10 \log_{10} e^{\frac{\rho(2\pi f)}{kc} \times X} \tag{10}$$

where

ρ = density of layer, gm/cc

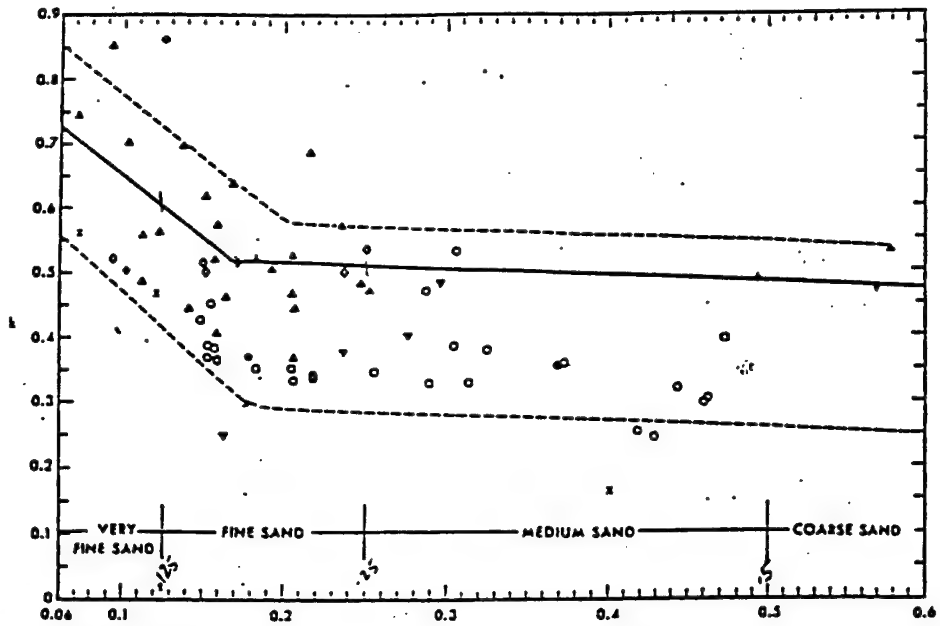
k = attenuation coefficient (similar to Hamilton's)

c = sound velocity of layer, m/sec

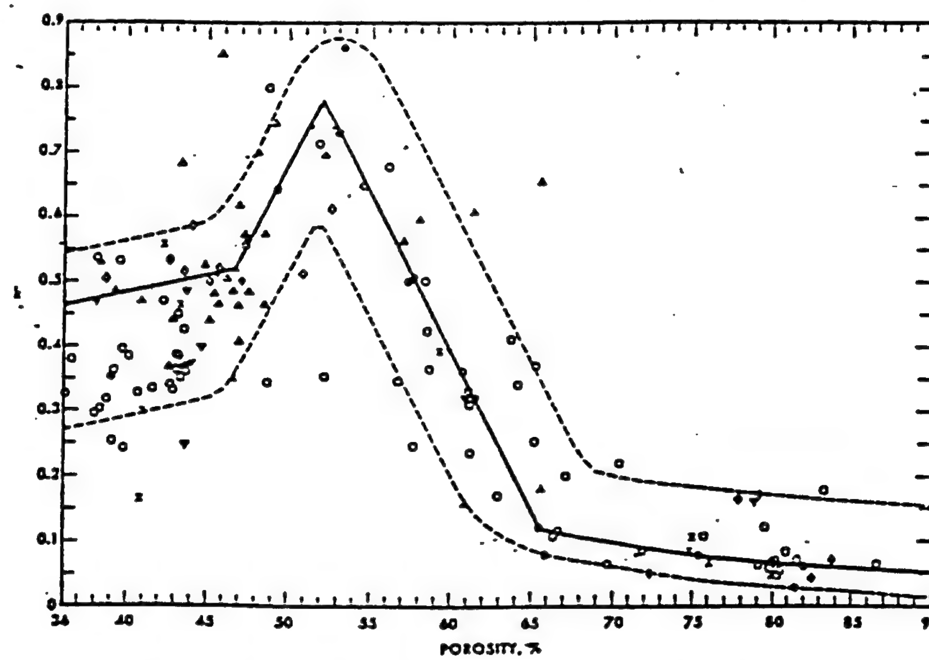
X = precision absorption correction factor

The coefficient k is either experimentally derived or estimated from Hamilton's regression equation (Figure 20), and the correction factor X is included to compensate for localized variations in the absorption properties of sediments in a given geologic setting. This value, termed the absorption factor, normally remains unity and is altered only when detailed core data are available, providing regional absorption data. The value is increased or decreased so that the deeper impedance estimates match the deeper core properties.

For the New Jersey coast project the absorption factor X remained unchanged (X = 12) from the Delaware coast acoustic impedance study. The absorption factor was determined in the Delaware coast study by comparing the rate of absorption in a given sediment across a range of frequencies. Since absorption varies linearly with frequency (Equation 9), the absorption



Mean grain size mm versus k (in $\alpha = kf^1$). Data, symbols, and remarks: same as in caption for Figure 3. Plot of mean grain size in mm emphasizes relationships in sands (see text). Regression equations for solid lines: Coarse, medium, and fine sand, in part (0.6 to 0.167 mm): $k = 0.5374 - 0.1113\ (M_z)$. Fine sand (in part), and very fine sand (0.167 to 0.063 mm): $k = 0.8439 - 1.9431\ (M_z)$.



Porosity n, percent, versus k (in $\alpha = kf^1$). Data, symbols, and remarks same as in caption for Figure 3. Regression equations for solid lines: Coarse, medium, and fine sand (36 to 46.7 percent): $k = 0.2747 + 0.00527\ (n)$. Very fine sand and lower-porosity mixed sizes (46.7 to 52 percent): $k = 0.04903\ (n) - 1.7688$. Mixed sizes (52 to 65 percent): $k = 3.3232 - 0.0489\ (n)$. Silt-clays (65 to 90 percent): $k = 0.7602 - 0.01487\ (n) + 0.000078\ (n)^2$.

Figure 20. Attenuation versus mean grain size and porosity (Hamilton 1972a)

coefficient can be evaluated by matching the impedance of a deep reflector from data of two or more frequencies. The absorption calibration was conducted by varying the absorption factors for the data at both frequencies until impedance calculations of the subbottom horizons for each frequency source matched. This process is summarized in Figures 21 and 22, taken from the Delaware coast study report (McGee 1995), showing the reflection data and impedance and density calculations at an *X* value of 12. Since the depositional environment is basically the same for the Delaware and New Jersey sites (i.e., Holocene depositional environment due to marine transgression), the acoustic absorption characteristics are considered equivalent.

Verification for the New Jersey area is provided via the acoustic core plots referenced on the sediment profiles (Chapter 7) and presented in Appendix B and the geoacoustic calibration plots in Figures 23-29. These calibration plots display a portion of the acoustic reflection data in the vicinity of the core followed by acoustically derived measures of impedance, density, and mean grain size. Laboratory measured values of density and mean grain size are also presented along with the USCS core lithology. The data presented at these calibration sites show good correlation between the acoustically derived and in situ measurements. Particularly encouraging is the assessment of polarity of the reflection coefficient. Figure 24 shows the correct prediction of a positive reflection sequence or increasing sediment impedance with depth. Figure 28 shows the opposite condition, a negative reflection sequence or a "softer" sediment underlying the surface sediment unit. This provides supporting evidence of the accuracy of the technique used to assess reflection coefficient polarity (see "Polarity of Reflection Coefficient" in Chapter 2).

Limitations

As with any remote sensing technique, limitations exist. The limitations must be understood to appropriately use the method. Probably the most common fault encountered in geophysical studies is the improper application of a given technique for a given study objective. Following is an overview of the major limitations with the present AI technique as well as project-specific problems:

Signal-to-noise ratio

The ability to accurately assess any environment is strictly a function of the quality of the data obtained. Low S/N data will produce poor quality results or possibly no results at all. The AI method limits its processing to data with a S/N ratio greater than 5 db. One must always be suspicious of impedance predictions in areas of poor S/N. Therefore, no analysis is performed on data of poor S/N (less than 5 db). The sediment profiles are annotated to identify poor S/N data.

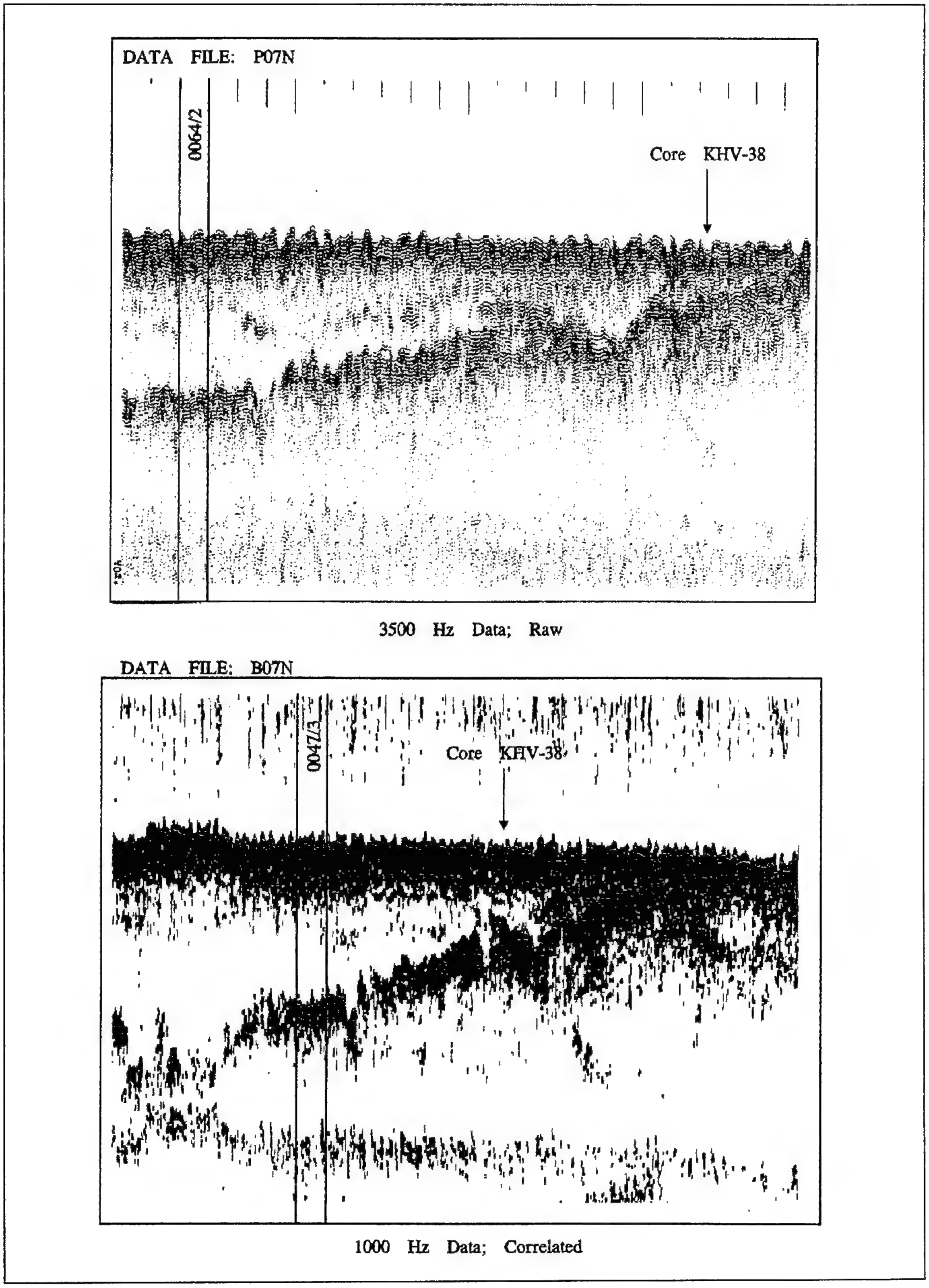


Figure 21. Reflection profiles: 3,500-Hz and 1,000-Hz data near core KHV-38 (McGee 1995)

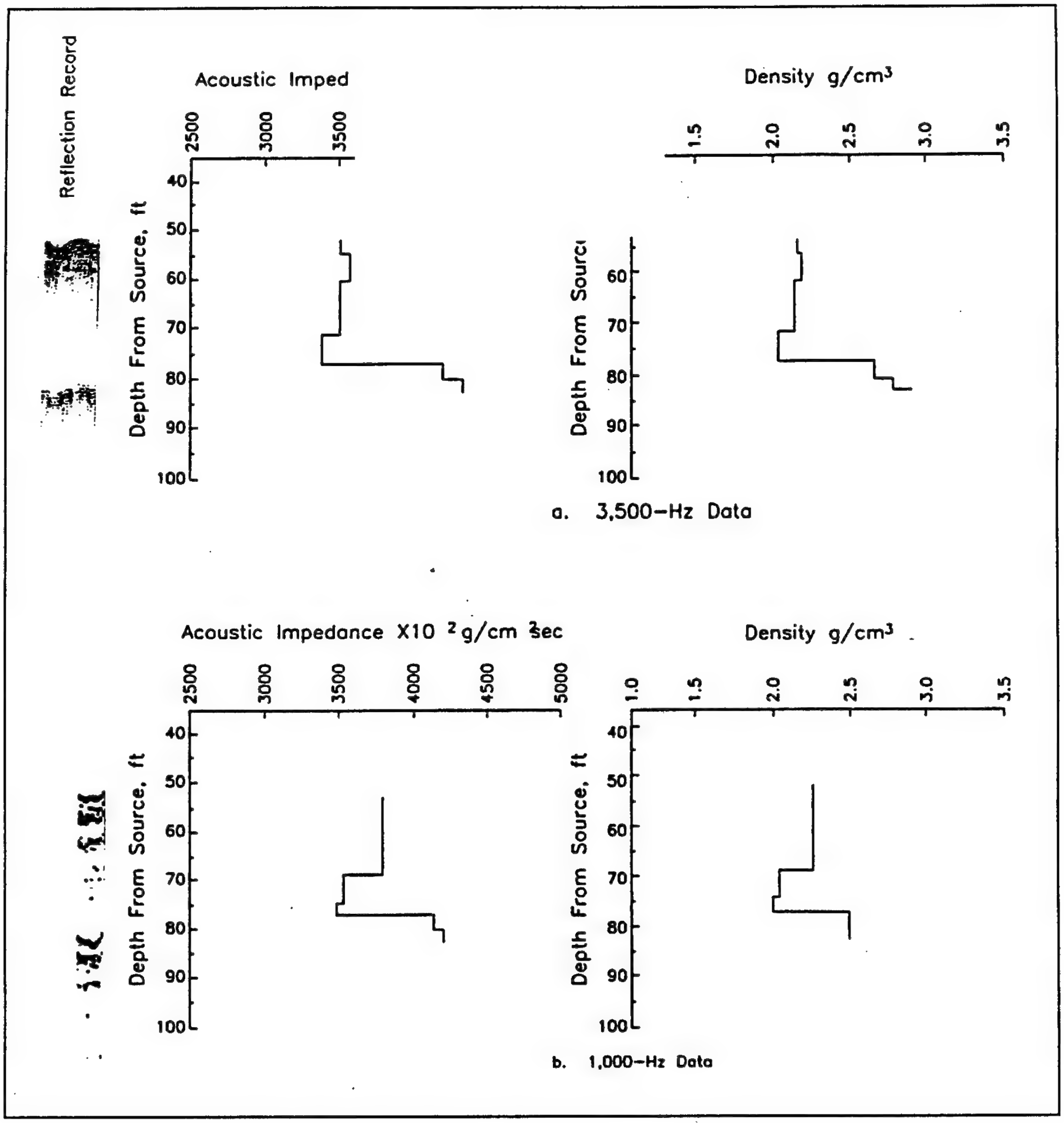


Figure 22. Absorption verification: impedance and density at 3,500 Hz (McGee 1995)

Layer identification

Unique sediment units can be identified only when an impedance change exists. Gradual changes in soil type may not result in an impedance differential large enough to produce a reflection.

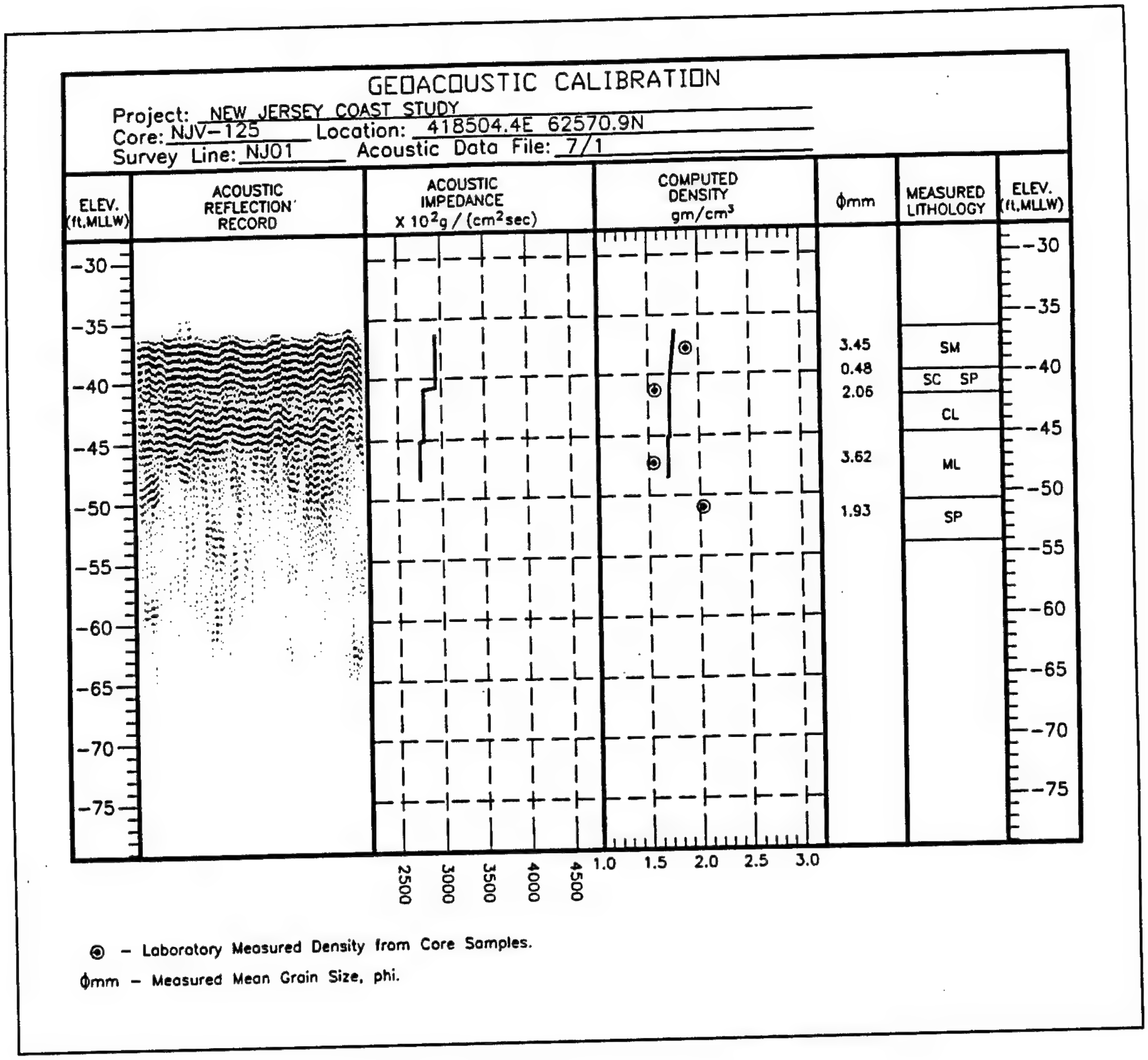


Figure 23. Geoacoustic calibration: NJV-125

Resolution

Vertical resolution and the ultimate depth of penetration are dependent primarily on the frequency of the sound wave. Higher operating frequencies permit greater resolution of the marine sediments but shallower depths of energy penetration depending on the characteristics of the subbottom materials. Also, in high-attenuation sediments, the higher frequencies are attenuated at a higher rate than the low frequencies, resulting in degradation of resolution and errors in absorption estimates for very deep layers. For this study, a pulse length of 1 msec was selected to improve the S/N; however, this limited the vertical resolution to about 2 ft. As stated earlier, depths were adjusted to match the high-accuracy fathometer depths, providing 10:1 improvement in the depth resolution.

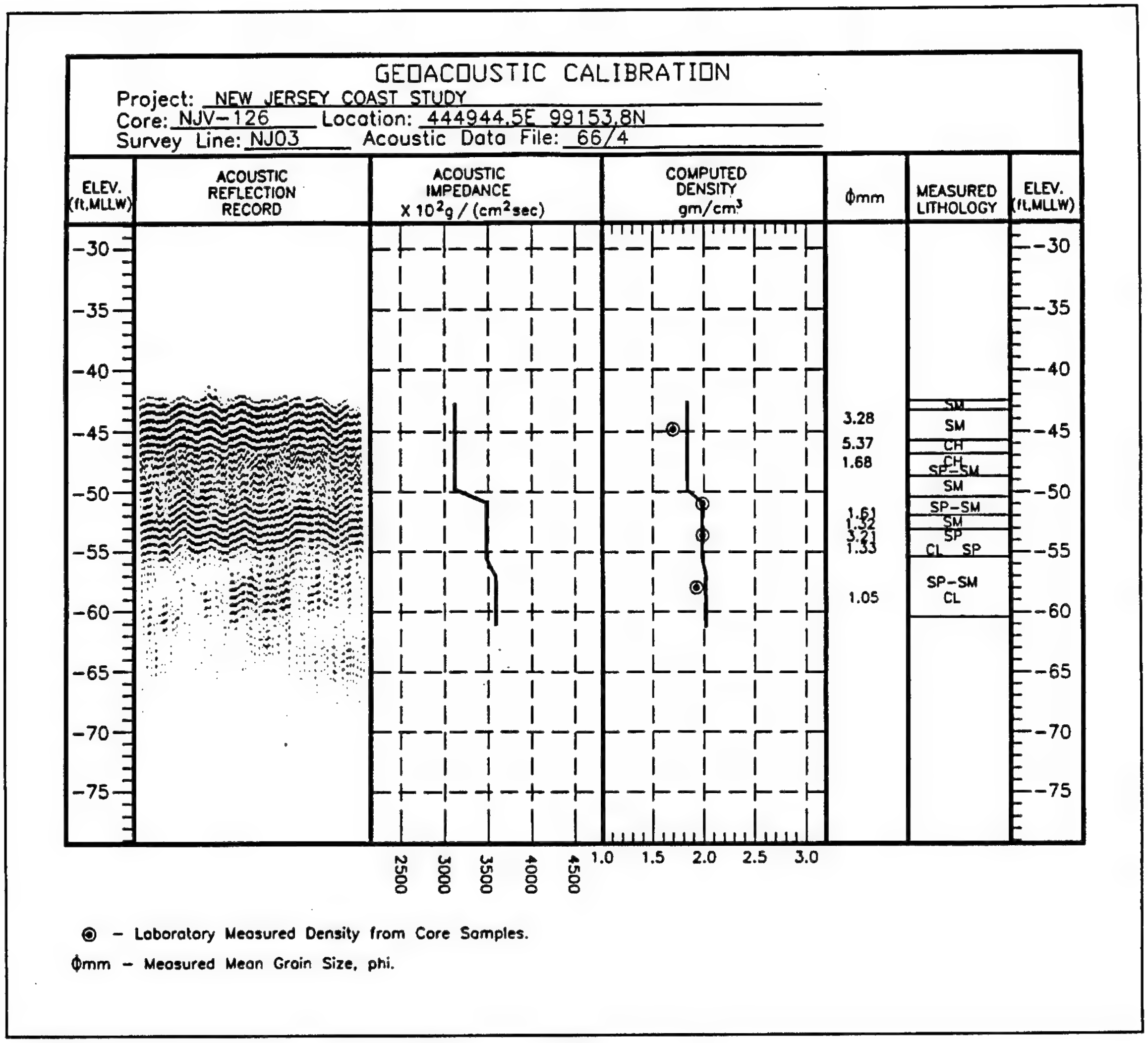


Figure 24. Geoacoustic calibration: NJV-126

The greatest effect the 1-msec pulse length had on the data was in the detection of sediment layers of less than 2 ft in thickness. Some of the cores indicated 6-in. to 1-ft layers of sand over silts and clays and others showed lenses of soft sediments between sand layers. Due to the pulse length, these layers are not always detected. Cores NJV-123 and NJV-124 are examples of this situation. The acoustic profile data in the vicinity of these cores are presented with the core log superimposed in Figures 30 and 31, respectively. Reflections occurring close together and multiple layers are not always apparent on the subbottom record. This can also cause problems in analytically detecting each reflection horizon. Should multiple material changes occur within the pulse length of the echo wavelet, detection of each interface may not occur. Appropriate notation is provided on the sediment profiles where this situation exists.

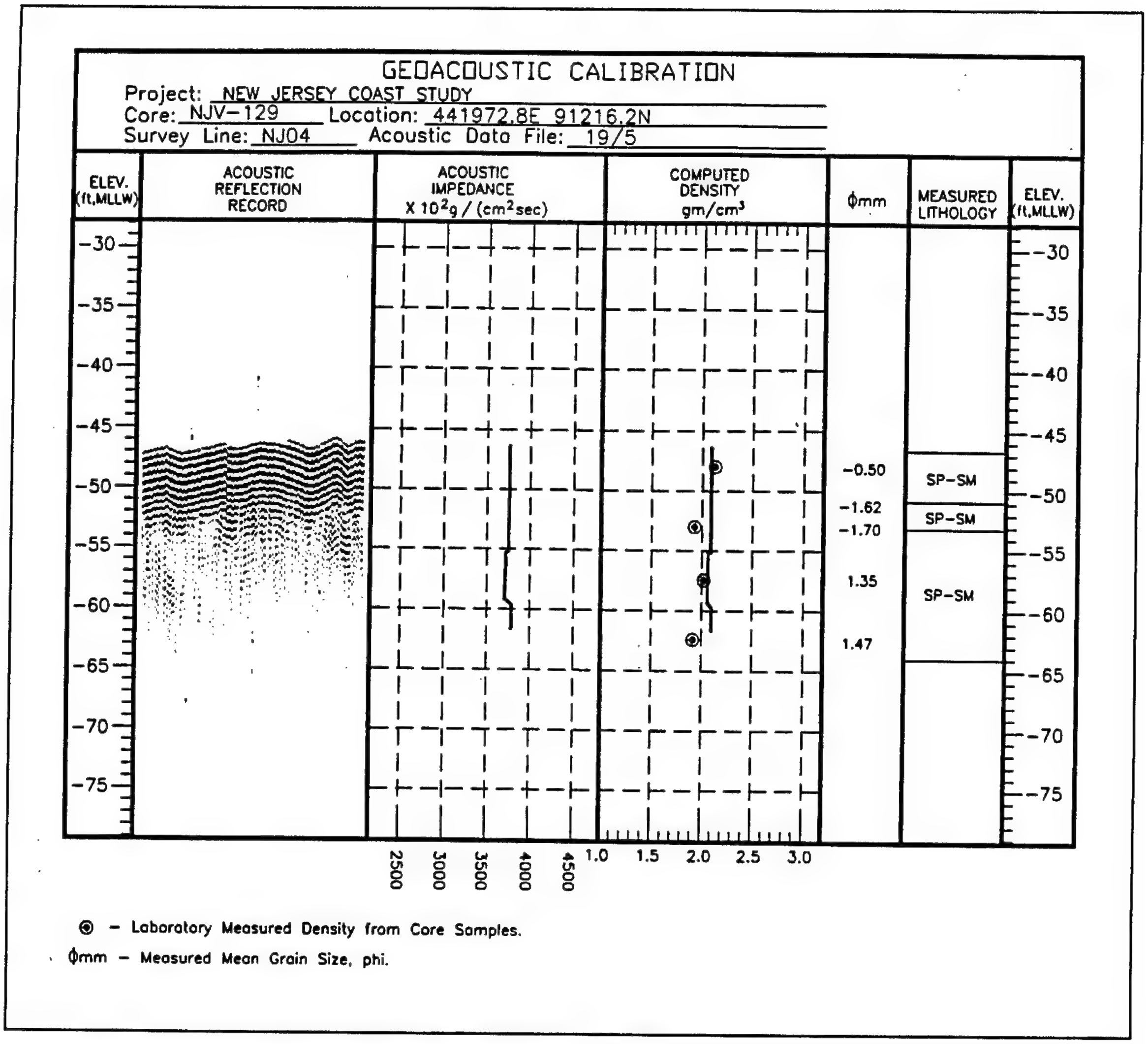


Figure 25. Geoacoustic calibration: NJV-129

Beam pattern or directivity

Experience has shown that beam pattern and transducer directivity contribute significantly to signal degradation. Sloping bottoms and rapidly dipping reflection horizons cause inconsistent reflection data through focusing and defocusing of the incident energy. Rough, irregular bottoms with numerous scatterers will specularly disperse energy away from the receiving array. Specific directivity problems and the approach to solving the problem are discussed in the "Equipment Calibration: Sources and Receivers" section.

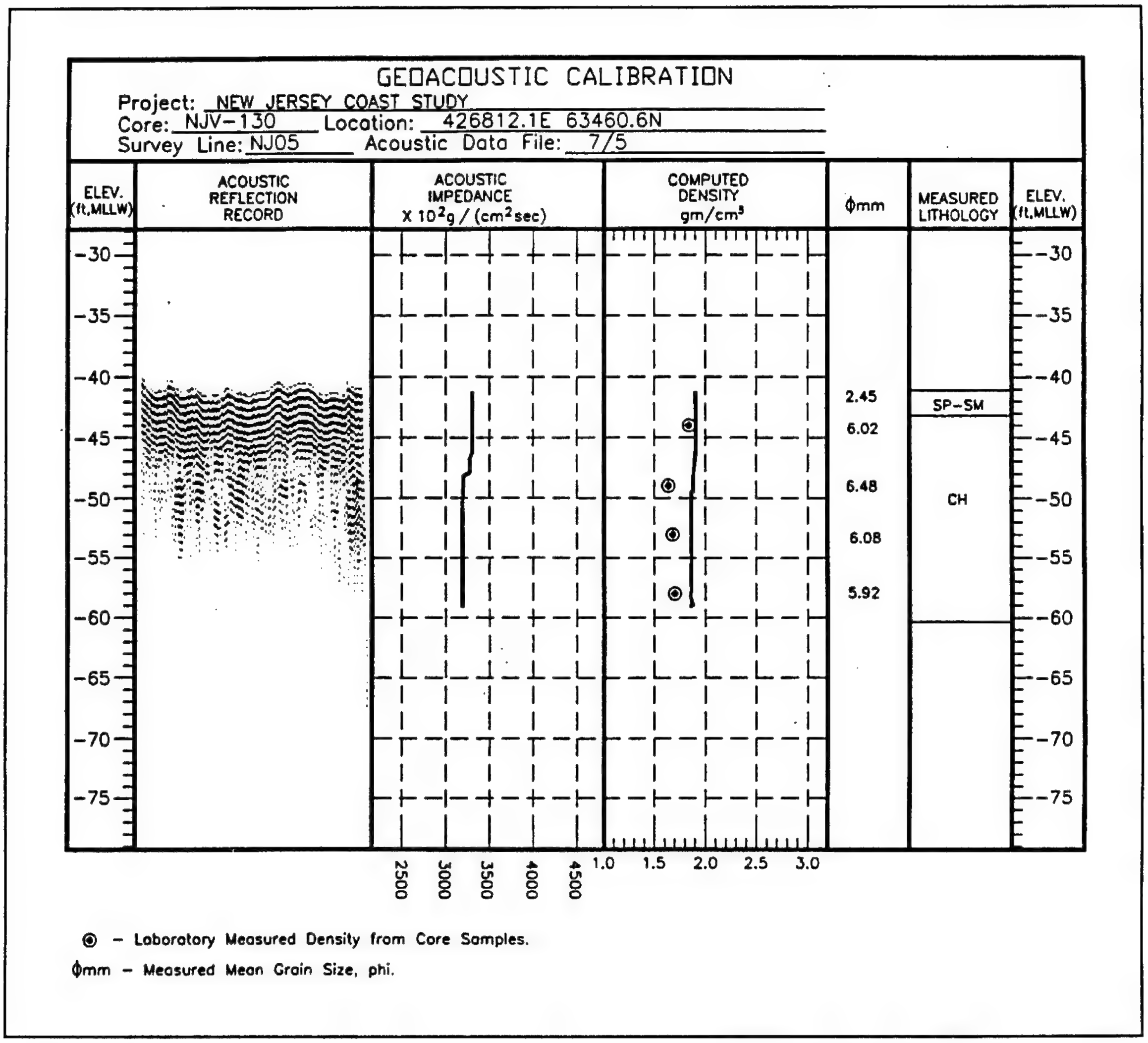


Figure 26. Geoacoustic calibration: NJV-130

Relatively shallow cores

Cores were collected to depths of 20 ft below the bottom. Since the objective of the study was to identify sediments in the uppermost 20 ft of the subsurface, the core depths would seem to be sufficient. In general, they are; however, in some areas of the study, significant subsurface anomalies and nonconformities were detected below the 20-ft depth, preventing absolute verification of the acoustically derived sediment properties. This was a factor in the vicinity of Core NJV-125 along lines NJ00-NJ03 (Plates 1-4) where a reflecting horizon was detected nearly 30 ft below the bottom and along line NJ05 between files 0350 and 0610 (Plate 6) where reflections were detected at depths greater than 20 ft. No coring was performed in the latter area.

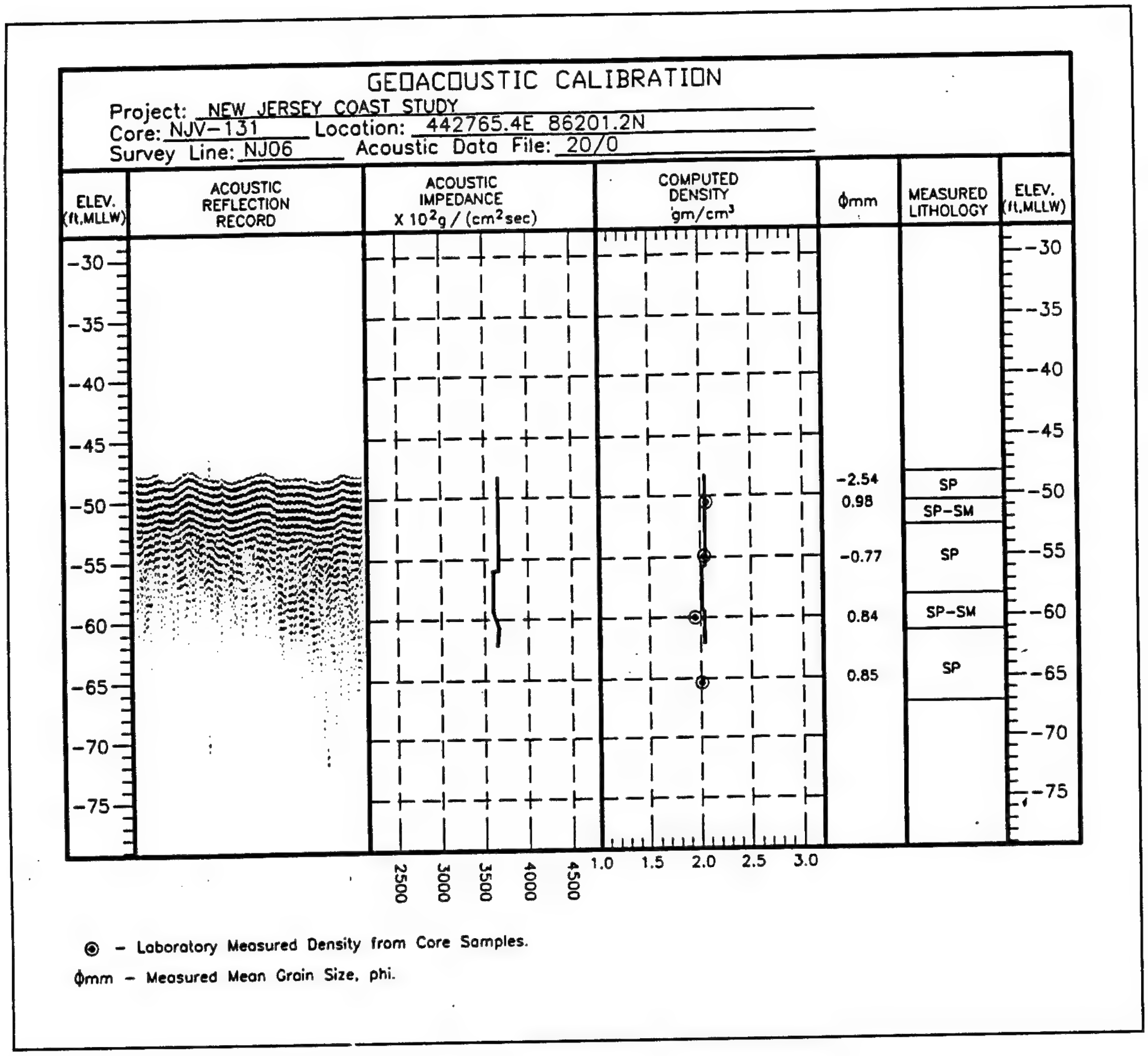


Figure 27. Geoacoustic calibration: NJV-131

Frequency

The "Absorption Calibration" section describes a technique for assessing absorption by comparing the rate of absorption in a given sediment across a range of frequencies. Two frequencies were operated during the survey, 3,500-Hz pinger, and 1,000-Hz boomer sources. In the presence of competent sands and gravels, acoustic penetration was severely limited with the pinger source, possibly preventing detection of material changes within the upper 20 ft of sediment. The boomer source, operated for the purpose of penetrating through these competent layers, did not always deliver data of sufficient S/N useful for analysis. Because the pinger was the only reliable data source, acoustic penetration is limited in some areas.

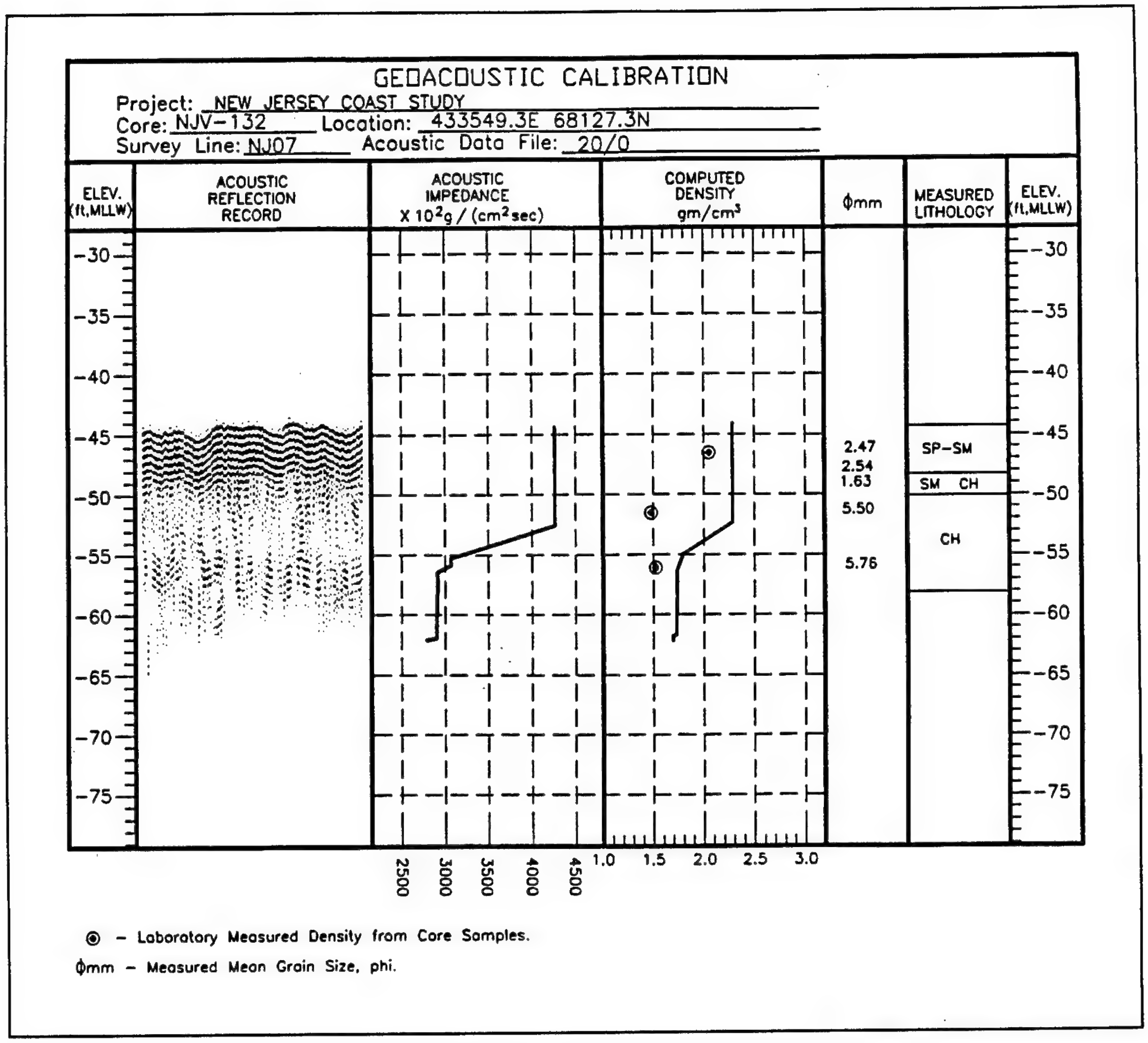


Figure 28. Geoacoustic calibration: NJV-132

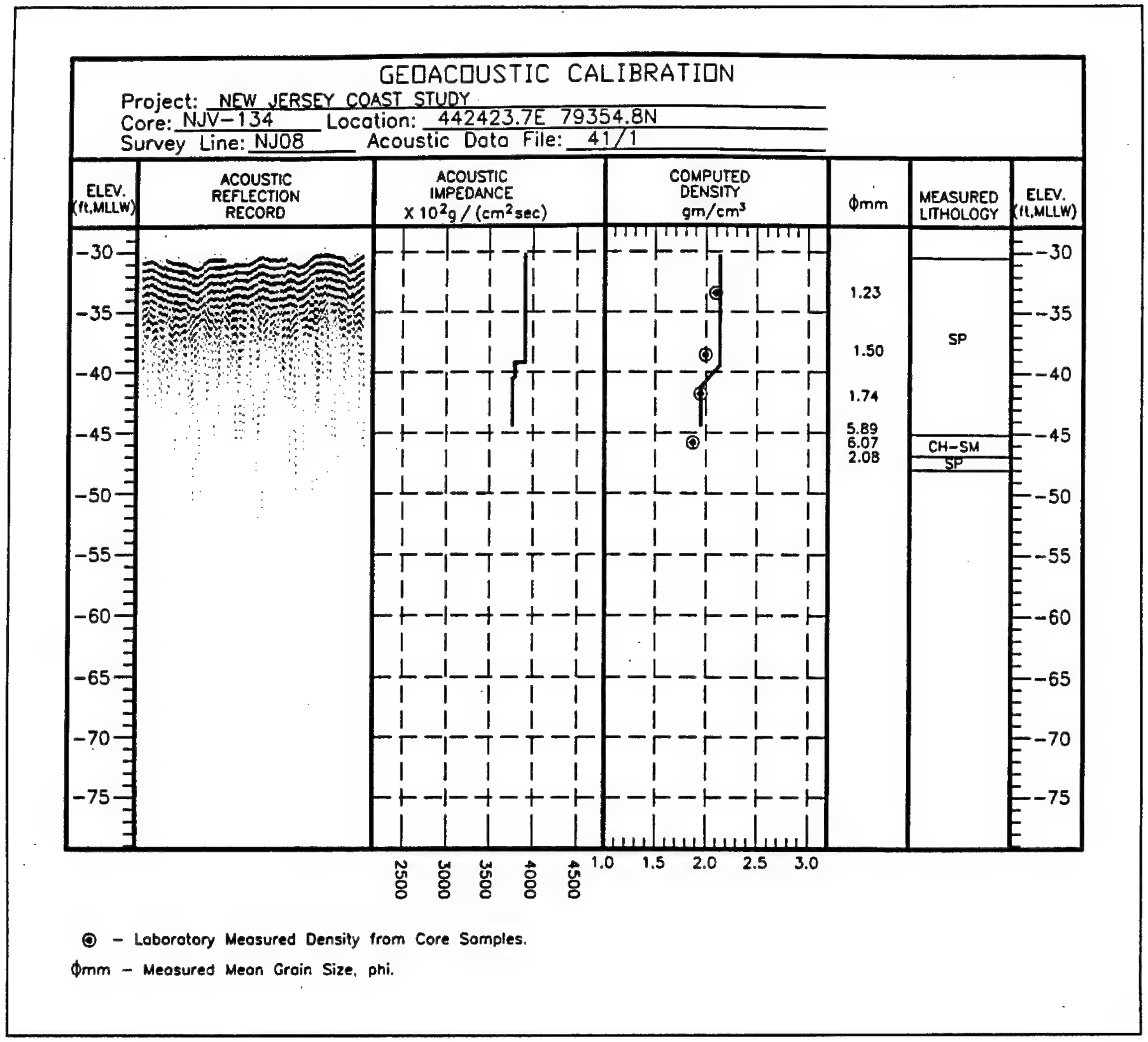


Figure 29. Geoacoustic calibration: NJV-134

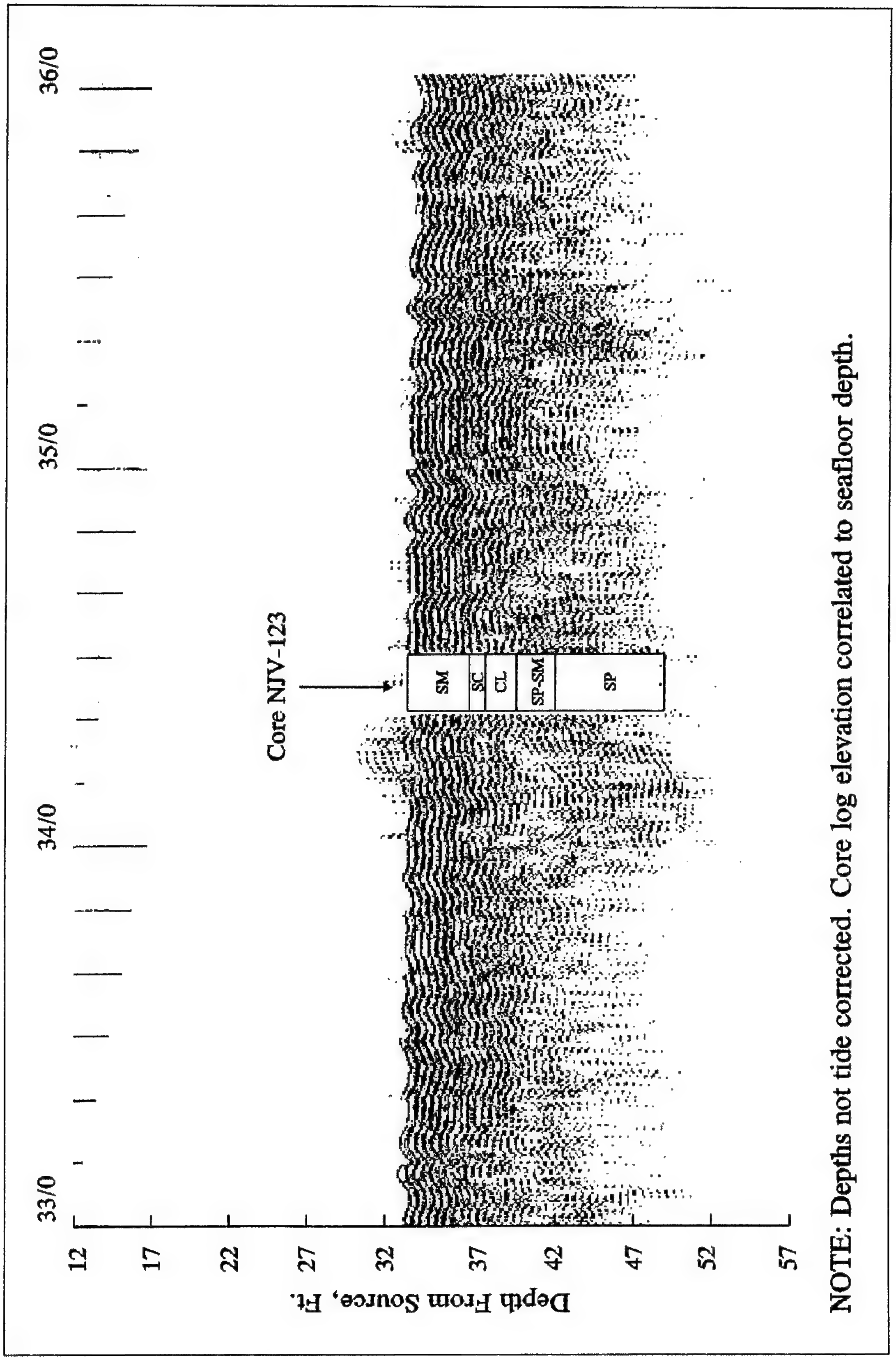


Figure 30. Acoustic reflection data and core lithology, Core NJV-123

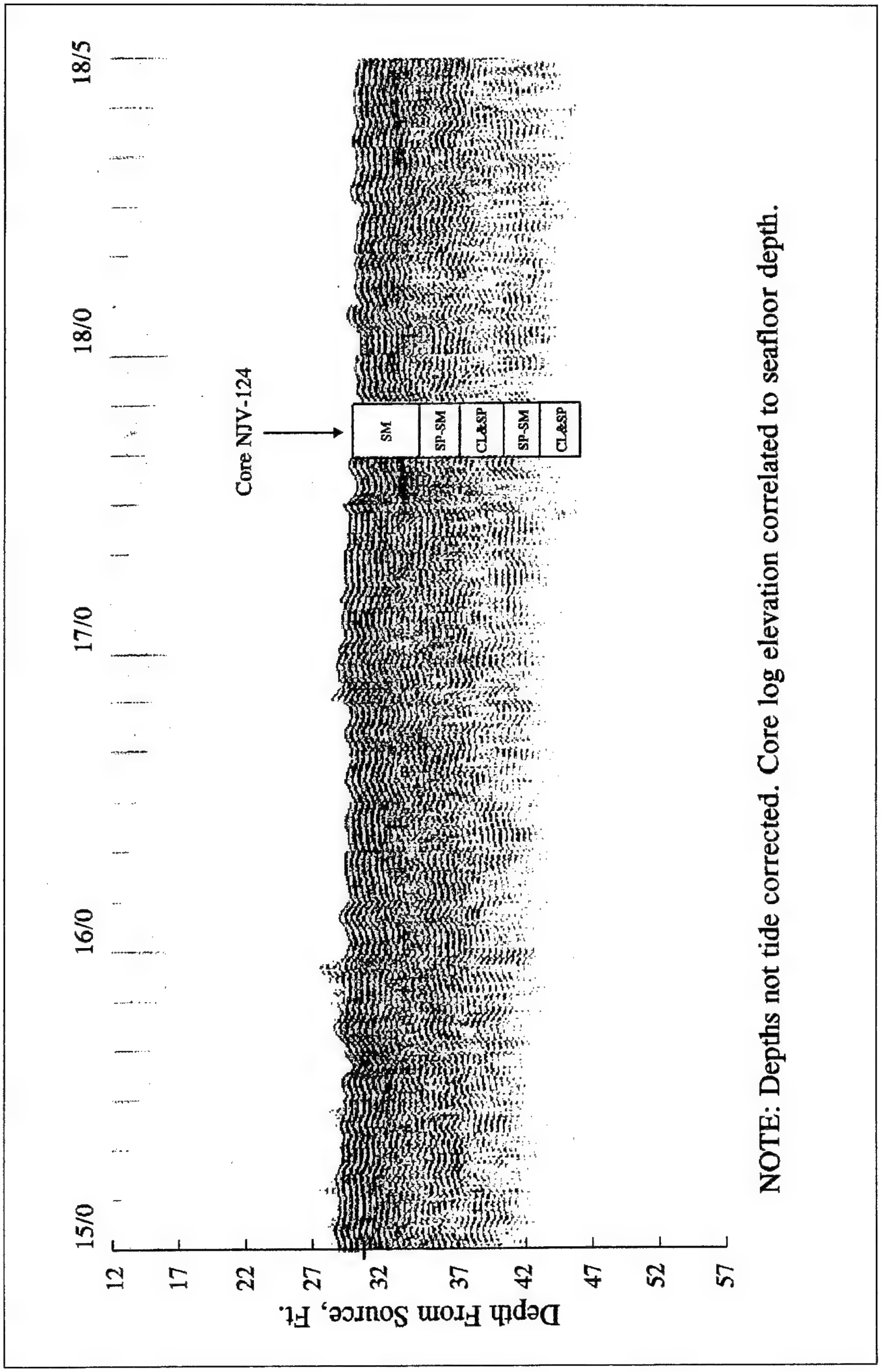


Figure 31. Acoustic reflection data and core lithology, Core NJV-124

7 Discussion of Results

Sediment Profiles

The distributions of computed sediment densities and mean grain sizes within the project area are presented in Plates 1-10 as two-dimensional profiles illustrating the primary bottom and subbottom interfaces and differing zones of sediment material. The profiles illustrate the depth to a particular interface, representative sediment properties, and corresponding location along the survey line. The labelled black dots at the top of each profile denote the survey track-line and direction. Each dot also represents the beginning of every seismic data file recorded to give an indication of the data coverage along each line and assist in correlating the raw data and interpreted results. The associated label represents the data file number and correlates with the data file number on the color subbottom reflection records (Figure 7). Lines of latitude are displayed on each profile. The sediment profiles have been completely adjusted for horizontal position (effects of boat speed) and survey heading. All profiles are presented heading in a northerly direction, allowing consistency in the data interpretation. Actual boat heading is in the direction of increasing data file numbers on the profiles.

Presented above each profile are plots of mean acoustic *BL* in db and the resultant mean surface sediment density in g/cm^3. These results are computed using Equation 8 as described in Chapter 6 in the section "Determination of Bottom Loss and Surface Reflection Coefficient." This presentation is important because it provides better assessment of the lateral variability in the sediment properties of the surface materials within hatched sediment units. All cores used during the study are identified and core logs plotted directly on the profiles. Also, locations where precision acoustic analysis was performed, or "acoustic cores," are presented. These sites are identified by the prefix AC followed by the line number and individual file number for that line, i.e., AC-06-41/5 is for line NJ06, file 41/5. All acoustic core density plots are presented in Appendix B.

Sediment Description

Sediments within the surveyed area consist primarily of marine sands, ranging from muddy silty sands to poorly graded sands and gravels. Two areas are identified within the survey that are characterized as consistently more competent materials compared with the remainder of the area. These are shown in Figure 32 as Area A and Area B. The upper sediments of Area A, located between Northings 60000 and 85000 along survey lines NJ05 through NJ08, are characterized as fine to medium poorly graded sand and are recommended for further evaluation as beach renourishment material. Area B is located between Northings 75000 and 95000 along portions of survey lines NJ02 through NJ06 and comprises surface sediments consisting of gravelly sands containing greater than 15 percent gravels. The remaining areas comprise complexly distributed sands, sandy gravels, and silts and clays possessing little vertical or lateral continuity.

Reflection sequences along the nearshore survey lines (NJ00-NJ03) are highly variable, indicative of discontinuous sediment distributions typical of heterogeneous sediment environments. Figure 33 is a typical reflection record for this area of the study. The lithology described in cores NJV-123, NJV-124, and NJV-126 (presented in Appendix A and shown in Plates 1 and 4) show layers of silty sands, fat clays, poorly graded sands, and lean clays. These sediment units are complexly distributed and are not uniformly stratified or laterally consistent as generally presented in the sediment profiles for these lines in Plates 1-4. Numerous pockets of fine sediments, less than 1.8 g/cm^3, are interspersed throughout the surface material. In Figure 34 the reflection data show considerable lateral surface sediment variability. This is identified in the figure by the color-coded amplitude variations in the reflection data (refer to Figure 7 for color-code definitions). This is also illustrated on the sediment profiles as acoustically derived bottom loss and density calculations for the surface materials. Surface densities vary laterally in this area between 1.4 and 2.1 g/cm^3. A prominent unconformity detected around el -50 and best presented in Plate 1 (line NJ00) is characterized as the top of a layer of poorly graded sand with a typical density between 2.0 and 2.2 g/cm^3. Between this interface and the bottom sediments lies a zone of intermittent clayey and silty sands with densities typically in the 1.6- to 1.8-g/cm^3 range. In general, the sediments along lines NJ00 through NJ03 are not considered suitable for further evaluation as beach material.

A significant paleochannel is detected at the southern end of survey lines NJ00-NJ06 (Plates 1-7), with the deepest reflector detected around el -80. This geologic structure is most likely a part of the ancient drainage system underlying the Hereford Inlet. The sediments filling this paleochannel consist of sandy silts and clays to silty sands as described in core NJV-125. Densities of the silts and clays were estimated between 1.4 and 1.6 g/cm^3. The upper surface of the fine sediments is between el -45 and -50 and is overlain by a

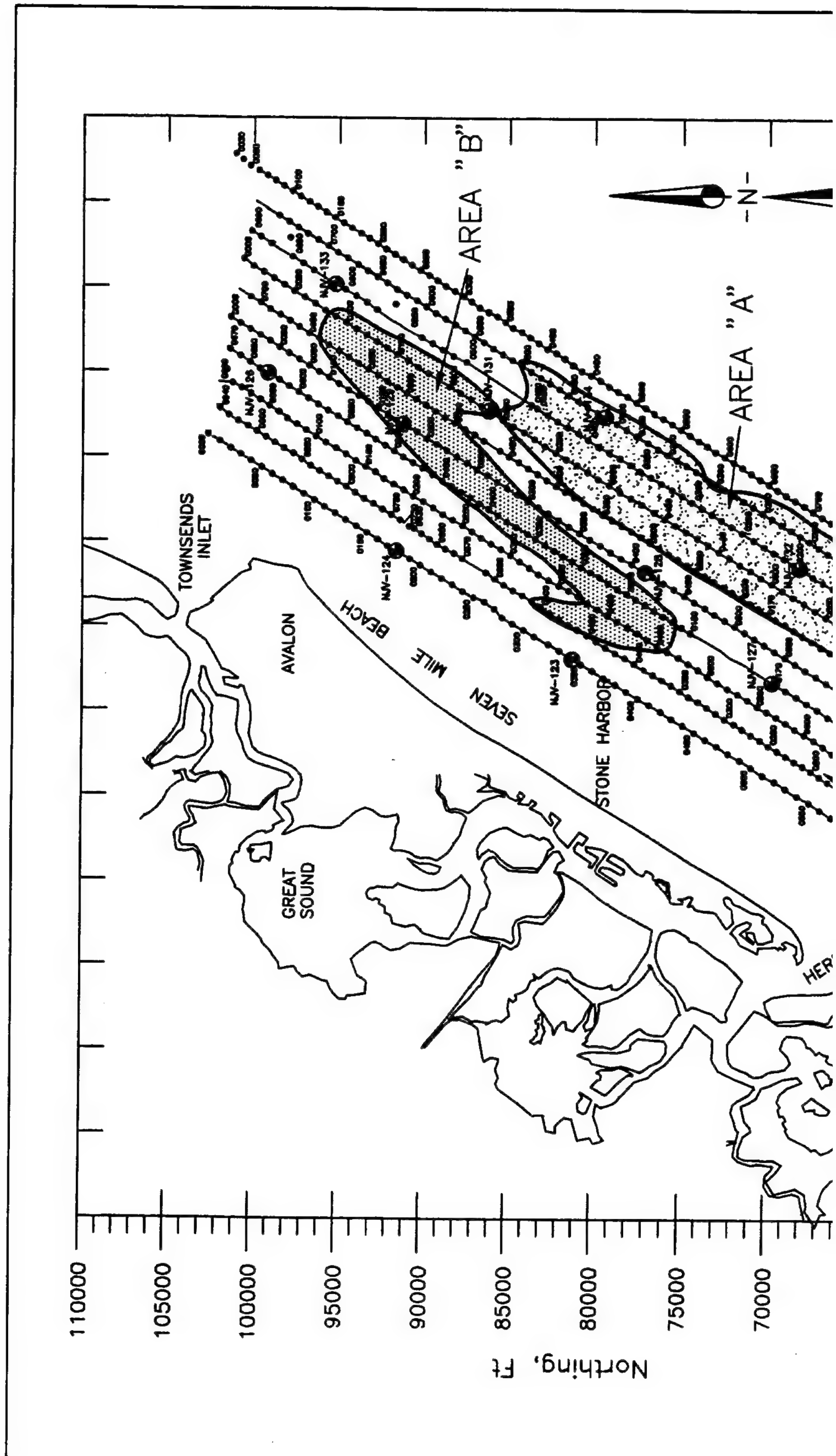
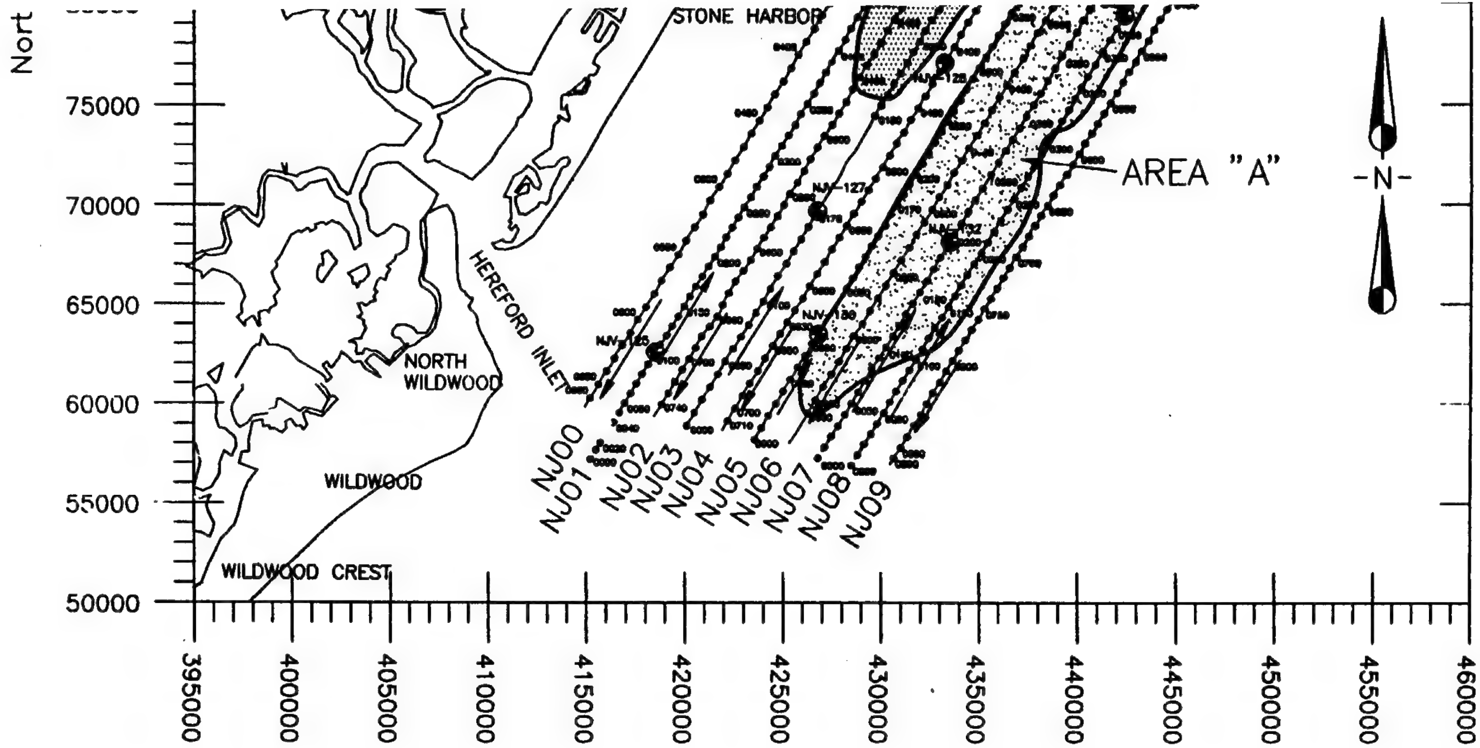


Figure 32. Potential sand sources



Easting, ft
New Jersey State Plane Coordinates

Depths in Ft MLLW
Contour Interval 1 Ft

LEGEND

- Core Location
- Survey Lines With Selected Digital Reflection Data File Numbers
- Area Recommended for Further Evaluation as Beach Renourishment Material
- Surface Sediments Consist of Sands Containing > 15% Gravels

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
POTENTIAL SAND SOURCES

FILE NAME: JERB.DWG		
SCALE: AS NOTED	DATE: NOVEMBER 30, 1995	SHEET

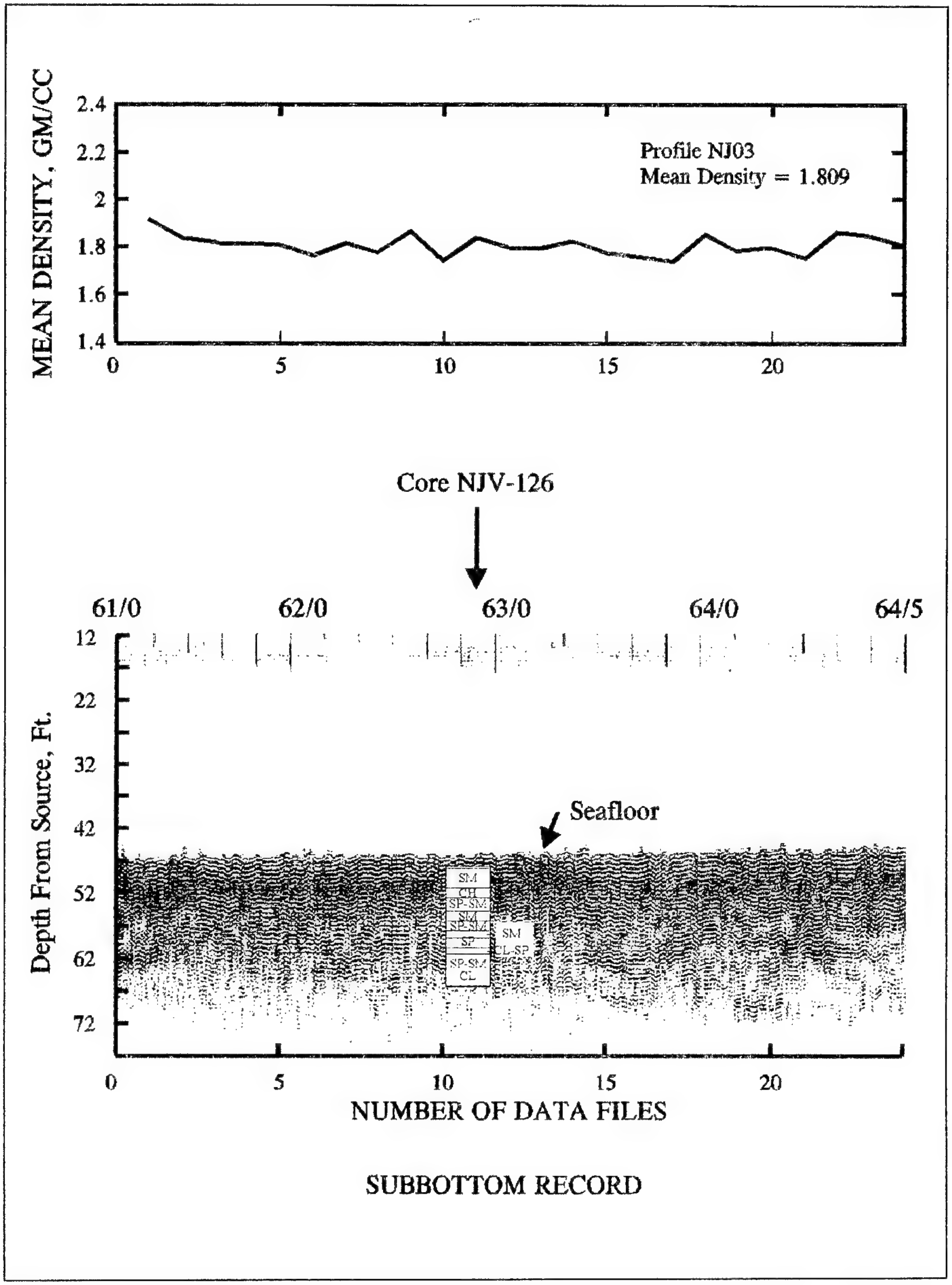


Figure 33. 3.5-kHz seismic profile data along line NJ03; digital files NJ030610-NJ03645

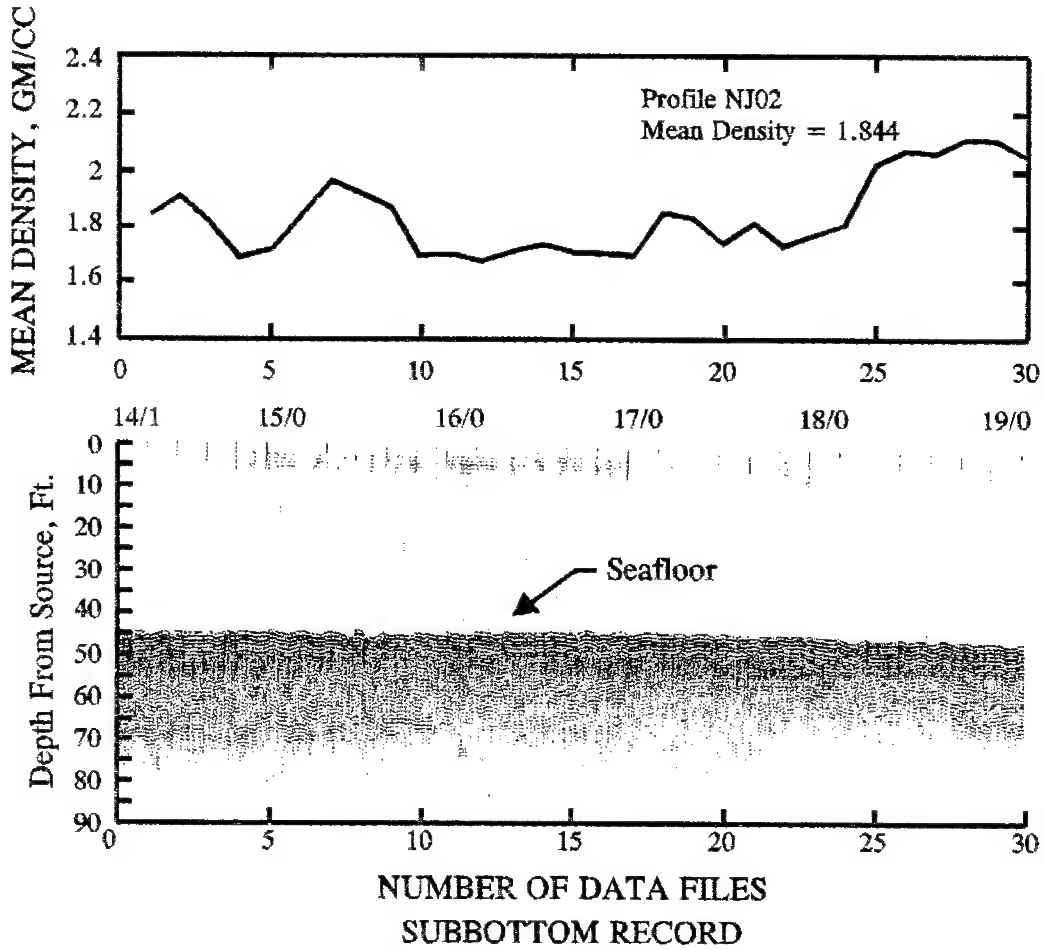


Figure 34. 3.5-kHz seismic profile data along line NJ02; digital files NJ020141-NJ020192

4- to 5-ft layer of silty sand with densities typically ranging between 1.8 and 2.0 g/cm^3. There is a high variability in the surface sediments as indicated by the density plots on the sediment profiles.

A sand shoal comprised of poorly graded (well-sorted) fine to medium sand, identified as Area A in Figure 32, is the area most likely to produce beach-fill materials. The sand shoals along the Continental Shelf off the New Jersey coast have been identified as primarily Holocene sands stranded during the marine transgression of the Holocene Epoch (Meisburger and Williams 1980). Analysis of acoustic data along line NJ06 (Plate 7) showed fine sands with densities up to 2.00 g/cm^3 with mean grain sizes between 2.2 and 1.2ϕ. Along lines NJ07 (Plate 8) and NJ08 (Plate 9), acoustic analysis showed sediment densities between 2.0 and 2.2 g/cm^3 and mean grain size estimates around 1ϕ. The cores located within the limits of Area A, NJV-130, NJV-132, and NJV-134 (Appendix A), corroborate the acoustic analysis. Laboratory densities were just above 2.0 g/cm^3 and mean grain size was measured to be near 2ϕ (Tables 2 and 4). Along the crest of the shoal, sediment thicknesses exceed 20 ft. The shoal overlays the pre-Holocene seafloor at approximately el -50 (Plates 7-10). The sediments for this seafloor unit are described on the sediment profiles as heterogeneous distributions of sands, gravels, silts, and clays complexly distributed with little lateral or vertical continuity. Densities range between 1.6 and 2.4 g/cm^3.

Area B, located in the central portions of lines NJ02 through NJ04 and the northern portions of lines NJ05 through NJ06 (Plates 3-7) has acoustically derived densities between 2.0 and 2.2 g/cm^3. The density computations are further described as laterally consistent with maximum deviations of $\pm$0.05 g/cm^3. Acoustic penetration in this area is limited, with only the surface reflection measured with the 3,500-Hz pinger. Core data suggest a fairly uniform stratigraphy. Cores NJV-129 and NJV-131, located in Area B, show poorly graded gravelly sands to depths of nearly 10 ft below the bottom transitioning to poorly graded sand. This stratigraphic sequence is not likely to produce an impedance differential sufficient to generate an acoustic reflection at this subbottom interface. The laboratory-tested density for the surface sample of core NJV-129 is 2.12 g/cm^3, correlating precisely with the acoustic densities (Figure 25).

Acoustic reflection data along the northern portion of the offshore survey lines, NJ06 through NJ09 (Plates 7-10), are also highly variable, the acoustically derived surface densities varying laterally between 1.6 g/cm^3 to 2.4 g/cm^3. The surface horizon, at approximately el -50, is presumed to be the pre-Holocene seafloor. The sediments in this area consist of heterogeneous distributions of sands, gravels, silts, and clays. They are distributed with little lateral or vertical continuity. Figure 35 is typical of this area and shows the lateral surface sediment variability in the acoustic reflection data as variable reflection amplitude response levels. This is also indicated by the

density plots (Plates 7-10). No significant subbottom interfaces were detected with the pinger.

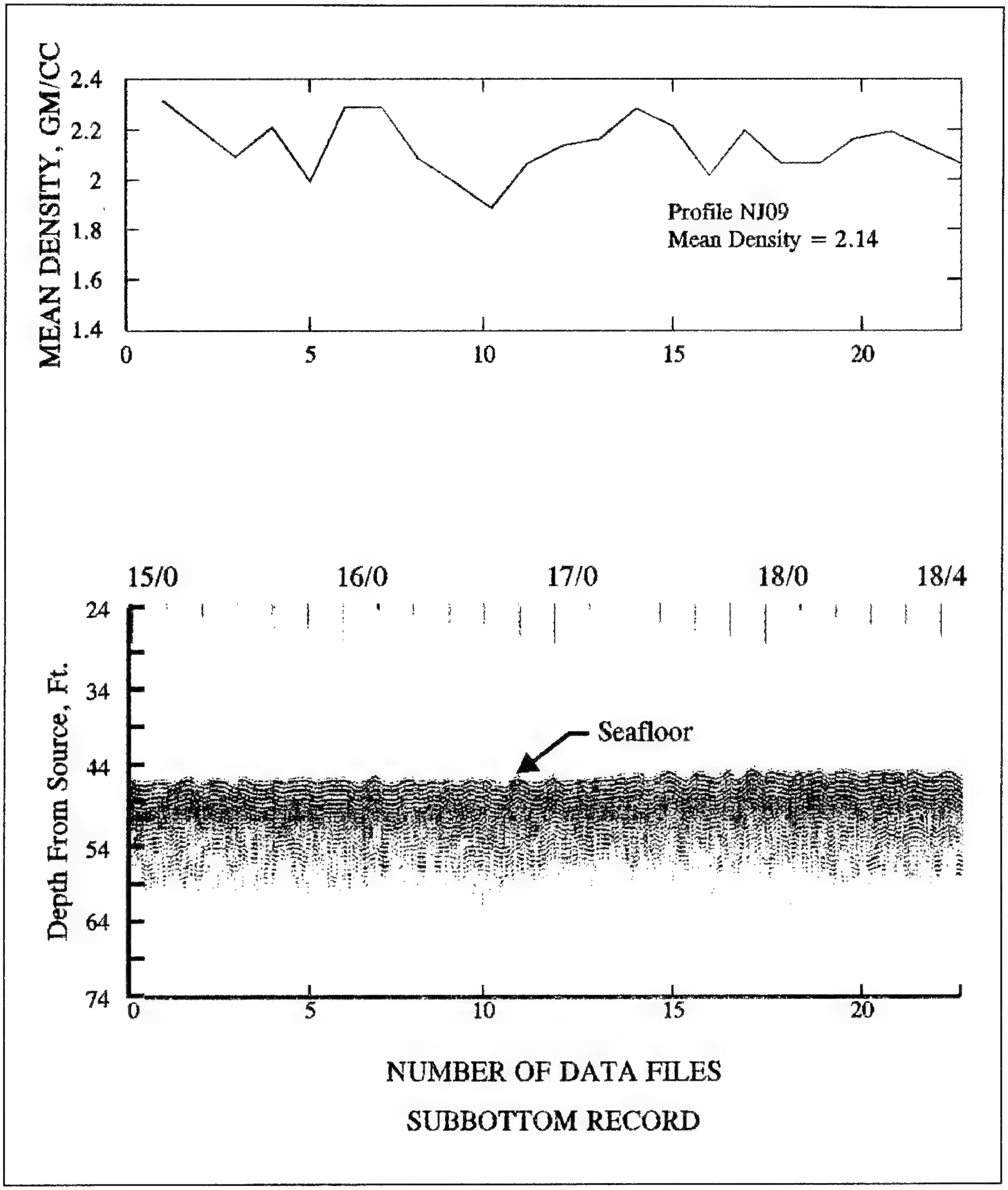


Figure 35. 3.5-kHz seismic profile data along line NJ09; digital files NJ090150-NJ090184

8 Project Summary

A comprehensive subsurface exploration program has been accomplished to establish possible limits of available granular materials for potential borrow areas for use as sources for beach fill. This being a reconnaissance-level investigation, the results are not intended to assess the suitability of any marine sediment as beach quality material; rather, the results are intended to pinpoint areas for further detailed investigation. Analysis of 3,500-Hz and 1,000-Hz seismic reflection data in conjunction with vibracore sampling data from selected sites throughout the New Jersey coast study area (Figure 1) has been completed. The seismic data were correlated with the laboratory analysis of the sample data through acoustic impedance analysis. The sediment characterization is presented as sediment profiles (Plates 1-10) presenting the major reflection facies with descriptions of the engineering properties, i.e., wet density, mean grain size, and associated soil types.

Discrepancies exist between the reported core depth elevations and the acoustic survey depth elevations, particularly along survey line NJ00. An independent survey should be conducted to clarify these differences.

The New Jersey coast sediment characterization developed to relate density, mean grain size, and soil type is provided in delineating the predominantly clay, silt, and sand sediment types. Using impedance versus density relationships from Hamilton and Bachman (1982) and McGee[1] (Figure 14) incorporated with the laboratory-determined densities from the New Jersey coast samples, an impedance versus density model was developed (Figure 16) providing acoustically derived density estimates within ±2.5 percent or ±0.05 g/cm^3. The empirically derived impedance-grain size function is presented in Figure 10. Between 0 and 3ϕ, acoustic impedance exhibits good correlation with the mean grain size parameter where for any given impedance value the resulting ϕ_{mc} is within ±0.5ϕ of the actual sample size. For grain sizes larger than 0ϕ (coarse sands and gravels and coarser) most of the impedance data points fall below the curve indicating that mean grain size estimates for impedances greater than about 3,800 × 10^2 g/cm^2 sec may

[1] R. G. McGee. (1991). "Subbottom hydro-acoustic survey of Gulfport Ship Channel," Memorandum for Record, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

possibly be low. No grain sizes are modelled greater than -2ϕ or smaller than 4ϕ.

A sand shoal comprising poorly graded Holocene sands, identified as Area A in Figure 32, is the area most likely to produce beach-fill materials. Analysis of acoustic data in conjunction with cores NJV-130, NJV-132, and NJV-134 describe fine to medium sand with densities between 2.0 and 2.2 g/cm^3 and mean grain sizes between 1 and 2ϕ. Sediment thickness at the crest of the shoal exceeds 20 ft.

An area consisting of gravelly sands containing greater than 15 percent gravels is located immediately northeast of the shoal and is identified as Area B in Figure 32. This area is possibly an outcropping of the Pleistocene. The remaining areas comprise complexly distributed sands, sandy gravels, and silts and clays possessing little vertical or lateral continuity. In general, sediments throughout these areas are not considered suitable for further evaluation as beach material.

The AI method attempts to estimate the engineering properties of bottom and subbottom marine sediments in a quantitative fashion. Whenever an assumption is made based on something other than mathematical processing, that assumption is stated. Also, whenever the data are not sufficiently high in S/N, no attempt at interpretation is made, except as verified by core data. Totally subjective interpretations are strictly avoided.

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Table 1
Geoacoustic Survey Vibracore Locations

Core Name	Date Collected	Location, New Jersey SP NAD 83		Core El	Survey El
		Easting	Northing		
NJV-123	25 October 1993	428177.3	81218.3	37.9	35.4
NJV-124	24 October 1993	434529.3	91598.9	37.9	33.2
NJV-125	25 October 1993	418504.4	62570.9	40.7	36.1
NJV-126	24 October 1993	444944.5	99153.8	47.2	42.8
NJV-127	25 October 1993	426723.4	69677.4	47.3	47.2
NJV-128	25 October 1993	433264.3	77064.2	48.2	45.6
NJV-129	24 October 1993	441972.8	91216.2	49.7	46.8
NJV-130	25 October 1993	426812.1	63460.6	48.5	46.0
NJV-131	25 October 1993	442765.4	86201.2	51.7	48.2
NJV-132	25 October 1993	433549.3	68127.3	47.2	44.2
NJV-133	24 October 1993	450230.2	95200.5	47.0	46.0
NJV-134	25 October 1993	442423.7	79354.8	30.4	30.4

Table 2
Core Analysis

Core ID	No.	Depth ft	Grain Size, ϕ				Distribution, %				Percent Moisture w	Wet Density g/cc	Sediment Type		
			D_{84}	D_{50}	D_{16}	Mean	Gravel	Sand	Silt	Clay			Shepard	USCS	Wentworth
123	1	-3.2	0.737	2.943	6.796	3.492	2	63	22	13	27.3	1.90	silty sand	SC	v. fine sand
	2	-4.8	4.238	10.909	??	7.574	0	8	43	49			silty clay	CL	silt
	3	-7.3	1.5564	2.252	7.059	3.622	0	79	8	13	21.6	1.92	clayey sand	SM	v. fine sand
	4	-10.4	1.0893	2.184	2.943	2.072	2	94	4		49.4	1.68	sand	SP	med. sand
	5	-15.0	3.059	1.474	2.474	2.336	9	88	3		12.3	2.18	sand	SP	fine sand
124	1	-3.0	2.6439	3.474	6.265	4.128	1	63	24	12	22.2	2.01	silty sand	SM	silt
	2	-8.0	2.5564	3.989	7.159	4.568	0	43	45	12	18.7	2.00	sandy silt	CL	silt
	3	-13.0	0.2176	1.184	3.059	1.487	0	88	12		12.0	1.89	sand	SP-SM	med. sand
	4	-16.0	1.000	4.133	8.288	4.474	0	42	40	18	20.3	1.94	silty sand	CL	silt
125	1	-1.5	2.943	3.490	4.211	3.548	0	66	27	7	26.7	1.88	silty sand	SM	v. fine sand
	2	-4.0	-1.000	2.737	6.966	2.901	8	62	17	13			silty sand	SC	fine sand
	3	-5.3	0.621	3.966	7.828	4.139	0	44	41	15	44.5	1.54	silty sand	CL	silt
	4	-11.1	2.556	3.816	8.078	4.817	0	49	34	17	61.0	1.52	silty sand	ML	silt
	5	-15.6	1.286	2.000	2.943	2.077	0	96	4		15.7	2.04	sand	SP	fine sand
126	1	-1.8	2.836	0.074	3.756	2.222	0	84	16				sand	SM	fine sand
	2	-3.7	4.011	6.796	9.288	6.699	0	12	57	31	45.7	1.67	clayey sily	CH	silt

(Sheet 1 of 5)

Table 2 (Continued)

Core ID	No.	Depth ft	Grain Size, ϕ				Distribution, %				Percent Moisture w	Wet Density g/cc	Sediment Type		
			D_{84}	D_{50}	D_{16}	Mean	Gravel	Sand	Silt	Clay			Shepard	USCS	Wentworth
126 (Cont.)	3	-5.0	0.713	1.644	7.311	3.223	0	78	10	12			clayey sily	SC	v. fine sand
	4	-9.5	0.599	1.889	4.211	2.233	1	80	12	7	21.8	1.96	sand	SM	fine sand
	5	-10.5	0.643	1.474	2.322	1.480	0	93	7				sand	SP-SM	med. sand
	6	-11.2	1.889	4.322	7.966	4.726	0	33	51	16			sandy silt	CL	silt
	7	-12.0	0.689	1.474	2.252	1.472	0	95	5		19.7	2.00	sand	SP-SM	med. sand
	8	-16.4	0.358	1.184	2.120	1.221	0	90	10			1.89	sand	SP-SM	med. sand
127	1	0.4	0.029	1.059	2.556	1.215	2	87	11				sand	SP-SM	med. sand
	2	-1.7	3.474	6.644	9.481	6.533	0	18	50	32	34.9	1.84	claey silt	CH	silt
	3	-5.6	0.811	1.690	7.533	3.345	2	71	13	14			clayey sand	SC	v. fine sand
	4	-7.0	1.000	1.600	2.184	1.595	0	92	8		17.7	2.14	sand	SP-SM	med. sand
	5	-11.3	-1.000	1.474	2.644	1.039	9	87	4		11.3	2.20	sand	SP	med. sand
	6	-11.9	-2.511	-0.379	1.556	-0.444	20	78	2				sand	SP	v.coarse sand
	7	-13.0	0.643	1.396	2.556	1.532	0	98	2		12.8	1.90	sand	SP	med. sand
	8	-16.4	-0.263	0.737	1.322	0.599	8	90	2				sand	SP	coarse sand
128	1	-2.4	2.000	6.673	8.966	5.880	0	28	45	27	34.1	1.72	sand-silt-clay	CH	silt
	2	-3.7	-3.46	0.286	2.184	-0.330	26	67	7				sand	SP-SM	v.coarse sand
	3	-6.7	0.251	1.286	2.000	1.179	2	94	4		7.0	1.96	sand	SP	med. sand

(Sheet 2 of 5)

Table 2 (Continued)

Core ID	No.	Depth ft	Grain Size, ϕ				Distribution, %				Percent Moisture w	Wet Density g/cc	Sediment Type		
			D_{84}	D_{50}	D_{16}	Mean	Gravel	Sand	Silt	Clay			Shepard	USCS	Wentworth
128 (Cont.)	4	-11.5	-0.585	0.737	1.474	0.542	8	88	4		5.4	1.98	sand	SP	coarse sand
	5	-16.4	-0.263	0.622	1.322	0.560	3	94	3		7.2	1.93	sand	SP	coarse sand
129	1	-1.5	-1.723	0.713	1.644	0.212	13	83	4		7.6	2.12	sand	SP	coarse sand
	2	-5.3	-3.07	0.916	1.889	-0.089	22	73	5				sand	SP-SM	v.coarse sand
	3	-6.4	-3.17	1.000	1.837	-0.111	20	77	3		7.2	1.91	sand	SP	gran. gravel
	4	-11.0	0.761	1.434	2.184	1.460	0	93	7		14.5	2.02	sand	SP-SM	med. sand
	5	-16.0	0.889	1.600	2.252	1.580	0	93	7		10.4	1.90	sand	SP-SM	med.sand
130	1	-0.7	2.000	2.474	3.059	2.511	3	89	2	6			sand	SP-SM	fine sand
	2	-3.0	4.756	7.098	9.118	6.991	0	10	53	37	36.4	1.85	clayey silt	CH	silt
	3	-8.0	5.265	7.405	9.288	7.320	0	1	58	41	52.8	1.65	clayey silt	CH	silt
	4	-12.0	4.836	7.059	8.966	6.954	0	1	64	35	52.9	1.67	clayey silt	CH	silt
	5	-17.0	4.836	6.381	8.703	6.640	0	2	66	32	50.5	1.69	clayey silt	CH	silt
131	1	-1.0	-3.907	-1.000	1.000	-1.302	41	55	4				sand	SP	gran. gravel
	2	-2.6	0.152	1.218	2.396	1.255	7	83	10		13.8	2.07	sand	SP-SM	med. sand
	3	-7.0	-1.888	0.000	1.218	-0.223	13	83	4		4.7	2.04	sand	SP	v. coarse sand
	4	-12.0	0.358	0.863	1.515	0.912	1	88	11		8.6	1.94	sand	SP-SM	gran. gravel
	5	-17.0	0.321	0.863	1.644	0.943	0	96	4		12.9	2.01	sand	SP	coarse sand

Table 2 (Continued)

Core ID	No.	Depth ft	Grain Size, ϕ				Distribution, %				Percent Moisture w	Wet Density g/cc	Sediment Type		
			D_{84}	D_{50}	D_{16}	Mean	Gravel	Sand	Silt	Clay			Shepard	USCS	Wentworth
132	1	-2.1	2.000	2.474	3.184	2.553	0	94	6		19.4	2.05	sand	SP-SM	fine sand
	2	-3.4	1.889	2.644	3.540	2.691	0	86	6	8			sand	SM	fine sand
	3	-4.6	0.358	2.474	7.381	3.404	2	55	28	15			silty sand	SM	v. fine sand
	4	-7.0	4.107	7.159	9.587	6.951	0	2	58	40	59.7	1.49	clayey silt	CH	silt
	5	-11.8	4.965	7.644	??	6.305	0	4	46	50	55.2	1.51	silty clay	CH	silt
133	1	-3.0	1.474	2.252	2.837	2.187	3	92	5		18	2.08	sand	SP	fine sand
	2	-4.8	4.059	8.703	??	6.381	0	15	26	59			silty clay	CH	silty sand
	3	-7.7	1.120	1.690	2.644	1.818	0	85	15		15.5	2.11	sand	SM	fine sand
	4	-8.7	1.474	2.644	3.474	2.531	0	57	32	11			silty sand	SC	fine sand
	5	-9.8	-3.17	-1.000	1.152	-1.006	31	65	4				sand	SP	gran. gravel
	6	-11.6	2.120	2.737	3.816	2.891	0	83	12	5			sand	SM	fine sand
	7	-12.5	-0.485	2.184	3.458	1.719	1	91	8		14.1	2.16	sand	SP-SM	med. sand
	8	-13.3	-2.723	-1.138	0.322	-1.179	21	78	1				sand	SP	med. sand
	9	-15.0	0.943	1.644	2.184	1.591	3	82	5				sand	SP-SM	med. sand
134	1	-2.9	0.713	1.358	1.837	1.303	0	99	1		15	2.10	sand	SP	med. sand
	2	-7.9	1.089	1.644	1.889	1.541	0	99	1		15.7	2.00	sand	SP	med. sand
	3	-11.4	1.058	1.943	2.556	1.853	0	97	3		12.9	1.97	sand	SP	med. sand

(Sheet 4 of 5)

Table 2 (Concluded)

Core ID	No.	Depth ft	Grain Size, ϕ				Distribution, %				Percent Moisture w	Wet Density g/cc	Sediment Type		
			D_{84}	D_{50}	D_{16}	Mean	Gravel	Sand	Silt	Clay			Shepard	USCS	Wentworth
134 (Cont.)	4	-14.7	5.011	8.533	??	6.772	0	7	36	57			silty clay	CH	silt
	5	-15.3	5.158	8.966	??	7.062	0	4	33	63	29.4	1.87	silty clay	CH	silt
	6	-16.4	1.643	2.120	2.644	2.136	0	97	3				sand	SP	fine sand

(Sheet 5 of 5)

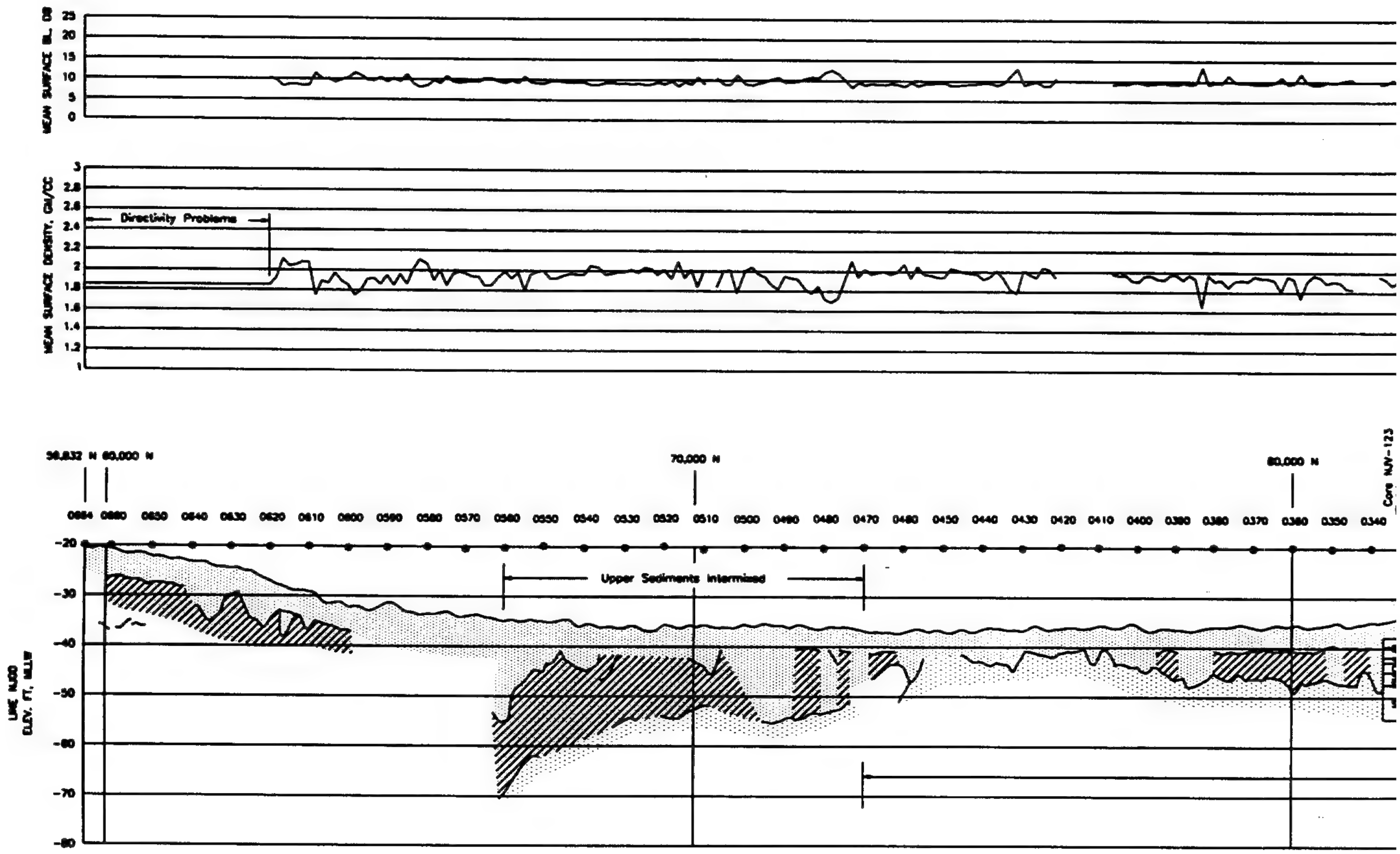
Table 3
Sediment Description

Density, g/cm^3	Mean Grain Size, ϕ_m	Basic Sediment Description
1.0 - 1.4	Outside model boundary	Soft muds, clays
1.4 - 1.6	>4	Clays, silts, sandy silts
1.6 - 1.8	4 - 2.2	Clayey sands, silty sands
1.8 - 2.0	2.2 - 1.2	Fine sands
2.0 - 2.2	1.2 - 0	Medium sands
>2.2	>0	Coarse sands and gravels, clayey sands w/gravels

Table 4
Sediment Properties Versus Acoustic Predictions for Selected Surface Samples, New Jersey Coast

Core Data (NJV only)					Acoustic Measurements				
ID	No.	Type[1]	ϕ_{mm}	ρ, g/cm3	Zx10^2g/cm^{2}s	R	BL[2] db	ϕ_{mc}	ρ,g/cm^3
123	1	SM	2.00	1.90	2876	0.32	10.00	1.90	1.90
124	1	SM	3.47	2.01	2946	0.33	9.71	1.77	1.92
125	1	SM	3.47	1.88	2953	0.33	9.68	1.76	1.92
129	1	SP-SM	-0.50	2.12	3277	0.37	8.55	1.01	2.06
132	1	SP-SM	2.47	2.05	3563	0.41	8.02	0.43	2.14
133	1	SP	2.08	2.08	3379	0.39	8.25	0.42	2.11
134	1	SP	2.10	1.23	2963	0.33	9.64	1.58	1.93

[1]Unified Soil Classification. Refer also to Table 2.
[2]$BL = 20 \log_{10}(R)$

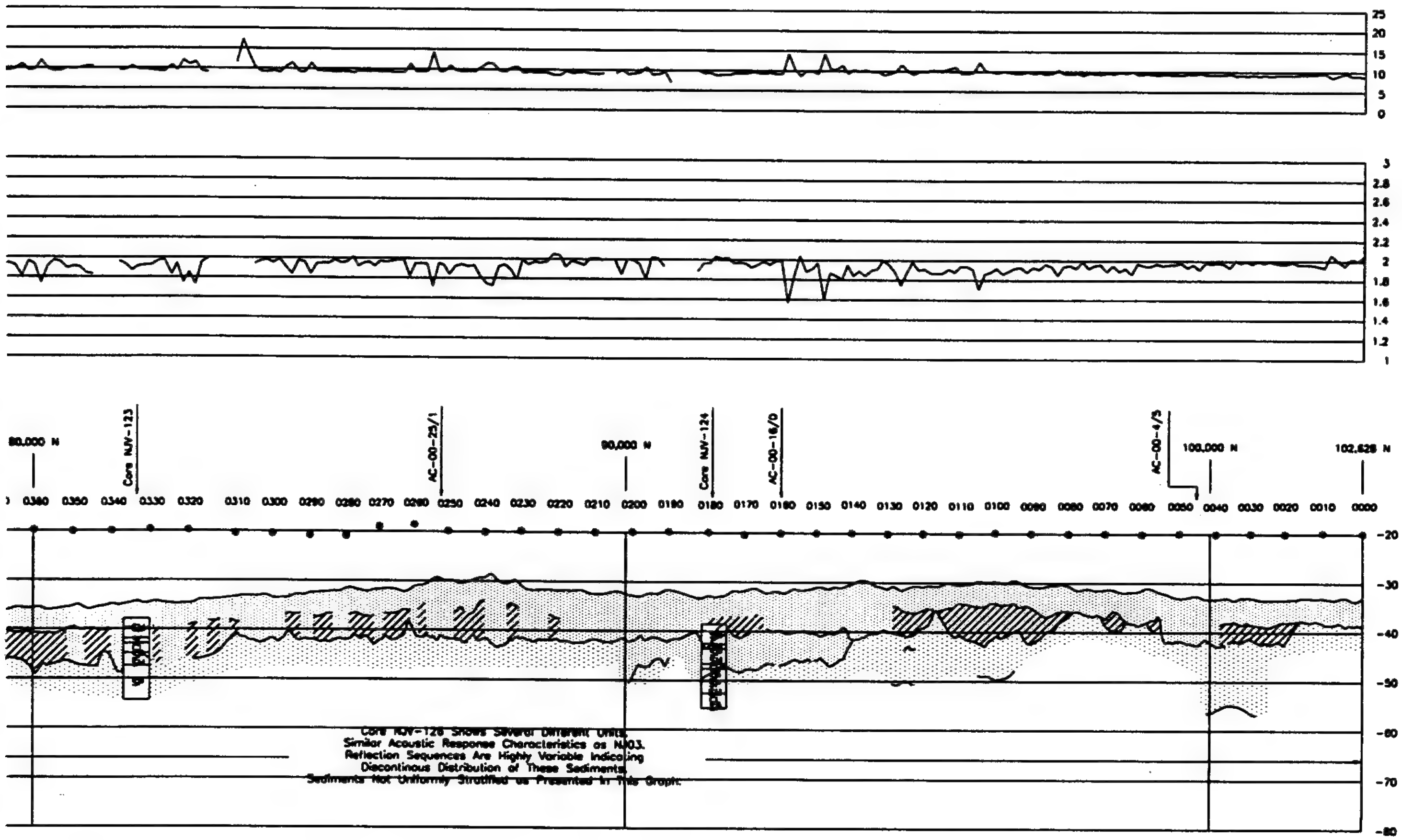


SCALE

0 1000 2000 Ft

NEW JERSEY COAST SEDIMENT DESCR			
Hatch Pattern	Density gm/cc	Mean Grain Size, ϕ m	Basic Descri
	1.0 - 1.4	Outside Model Boundary	Soft Muds, (
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sand
	> 2.2	> 0	Coarse Sand Clayey Sand
	1.6 - 2.4	—	See Note 1

V.E. = 100



SCALE

1000 2000 Ft

T SEDIMENT DESCRIPTION	
lean Grain Size, ϕ m	Basic Soil Description
utside Model Boundary	Soft Muds, Clays
> 4	Clays, Silts Sandy Clay Sandy Silt
4 - 2.2	Clayey Sands Silty Sands
2.2 - 1.2	Silty Sands Fine Sands
1.2 - 0	Medium Sands
> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
——	See Note 1

:. = 100

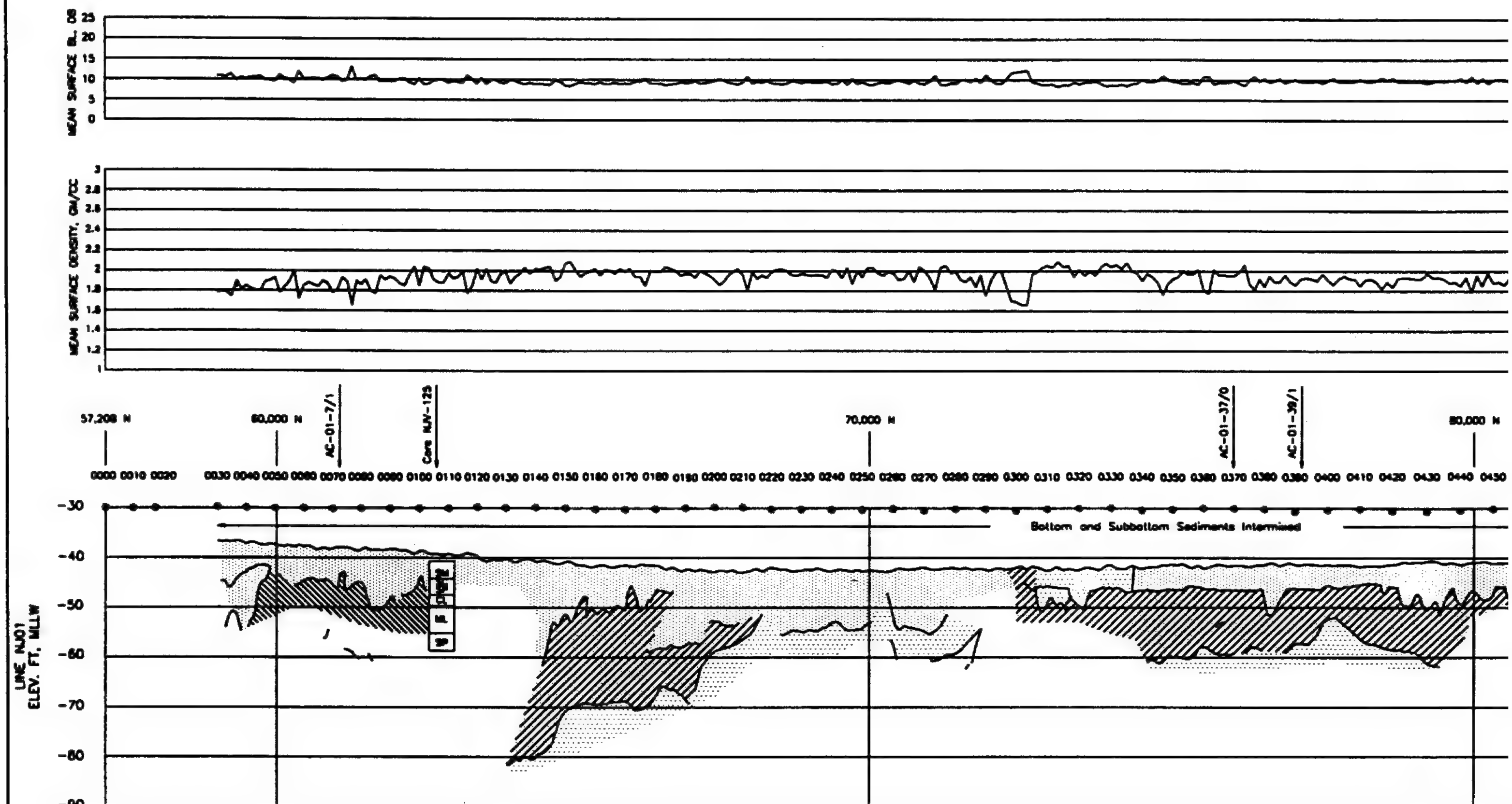
WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ00

FILE NAME: NJ00.DWG

SCALE: AS NOTED | DATE: NOVEMBER 30, 1995 | SHEET

Plate 1

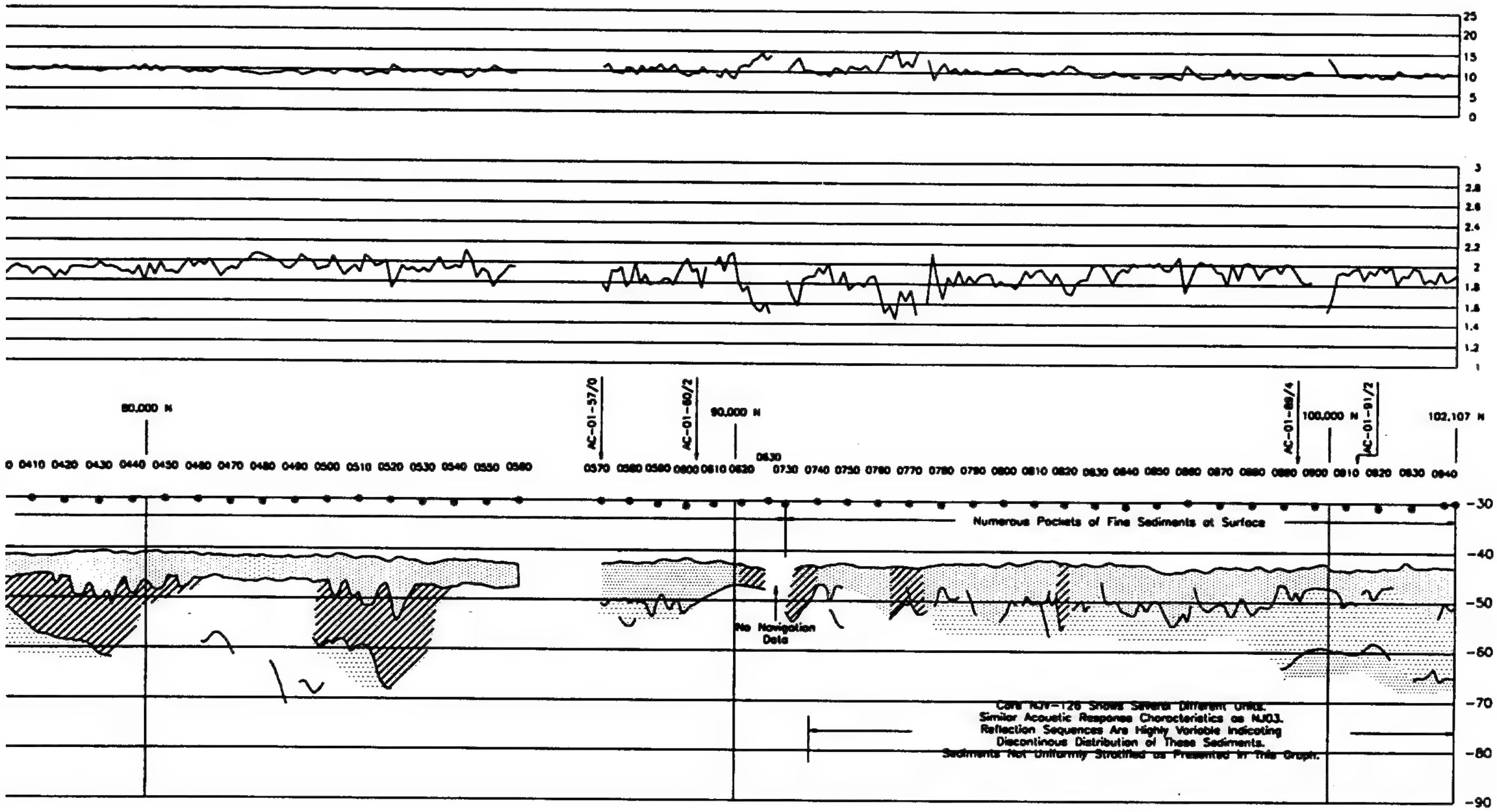


SCALE

0 1000 2000 Ft

NEW JERSEY COAST SEDIMENT DESCRIPTIO			
Hatch Pattern	Density gm/cc	Mean Grain Size, Φ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & G Clayey Sands w/ G
	1.6 - 2.4	——	See Note 1

V.E. = 100



SCALE

1000 2000 Ft

ST SEDIMENT DESCRIPTION	
Mean Grain Size, Φ m	Basic Soil Description
Outside Model Boundary	Soft Muds, Clays
> 4	Clays, Silts Sandy Clay Sandy Silt
4 - 2.2	Clayey Sands Silty Sands
2.2 - 1.2	Silty Sands Fine Sands
1.2 - 0	Medium Sands
> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
——	See Note 1

.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ01

FILE NAME: NJ01.DWG

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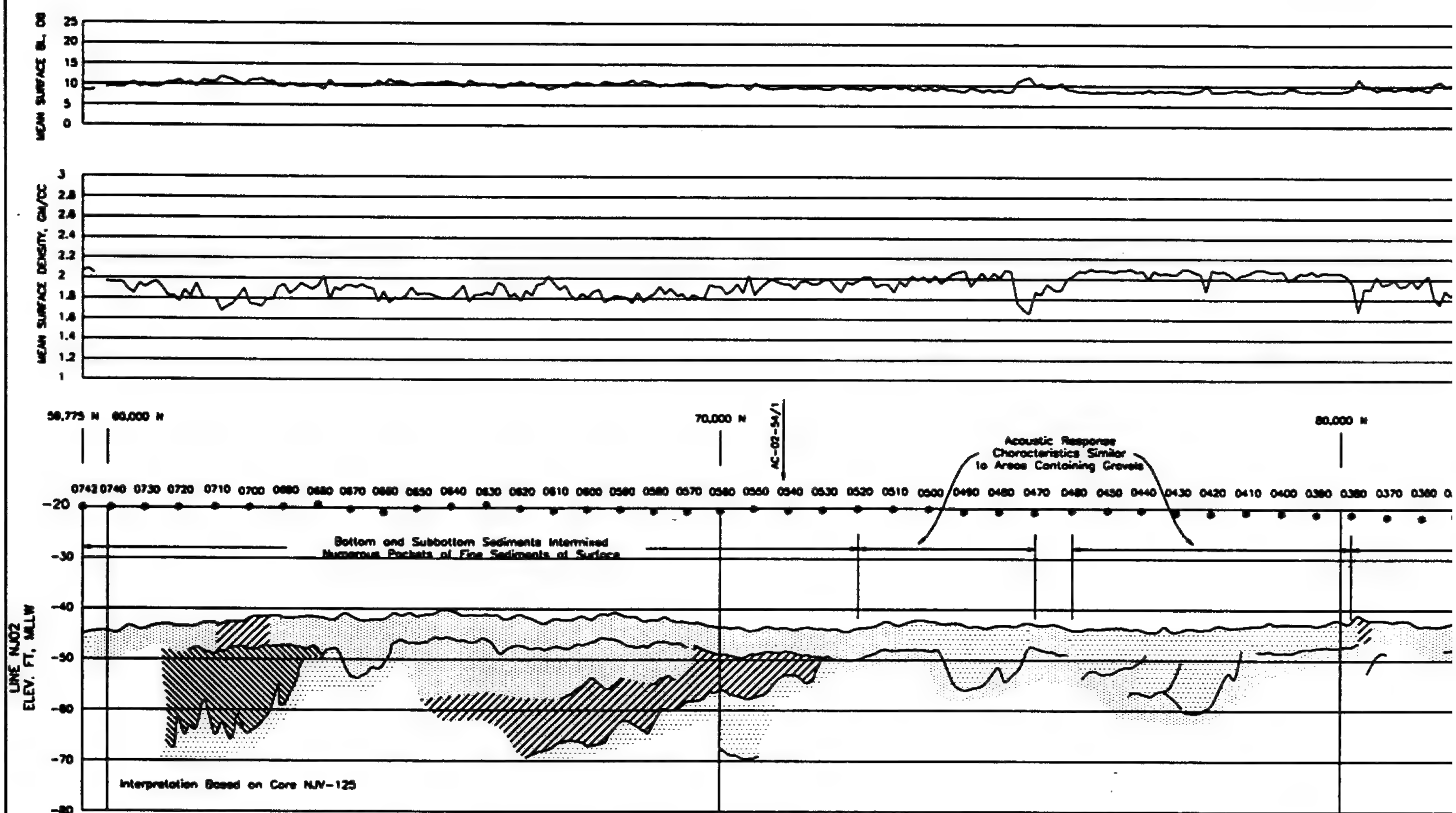
Plate 2

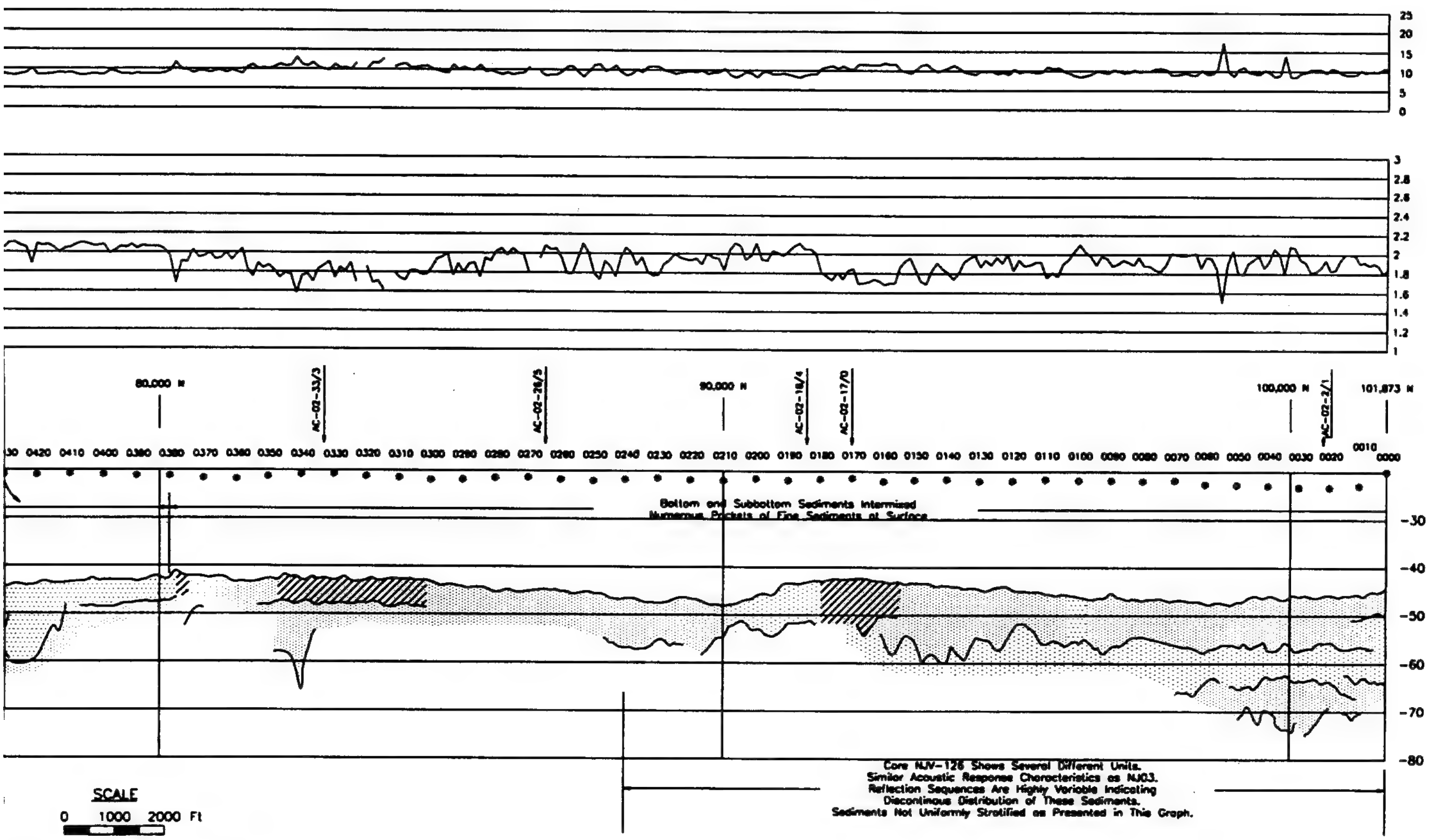


SCALE

0 1000 2000 Ft

NEW JERSEY COAST SEDIMENT DESCRIPTION			
Hatch Pattern	Density gm/cc	Mean Grain Size, Φ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & Grave[illegible] Clayey Sands w/ Grav[illegible]
	1.6 - 2.4	——	See Note 1

V.E. = 100



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JERSEY COAST SEDIMENT DESCRIPTION		
Density gm/cc	Mean Grain Size, ϕ m	Basic Soil Description
1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
2.0 - 2.2	1.2 - 0	Medium Sands
> 2.2	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
1.6 - 2.4	——	See Note 1

V.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ02

FILE NAME: NJ02.DWG

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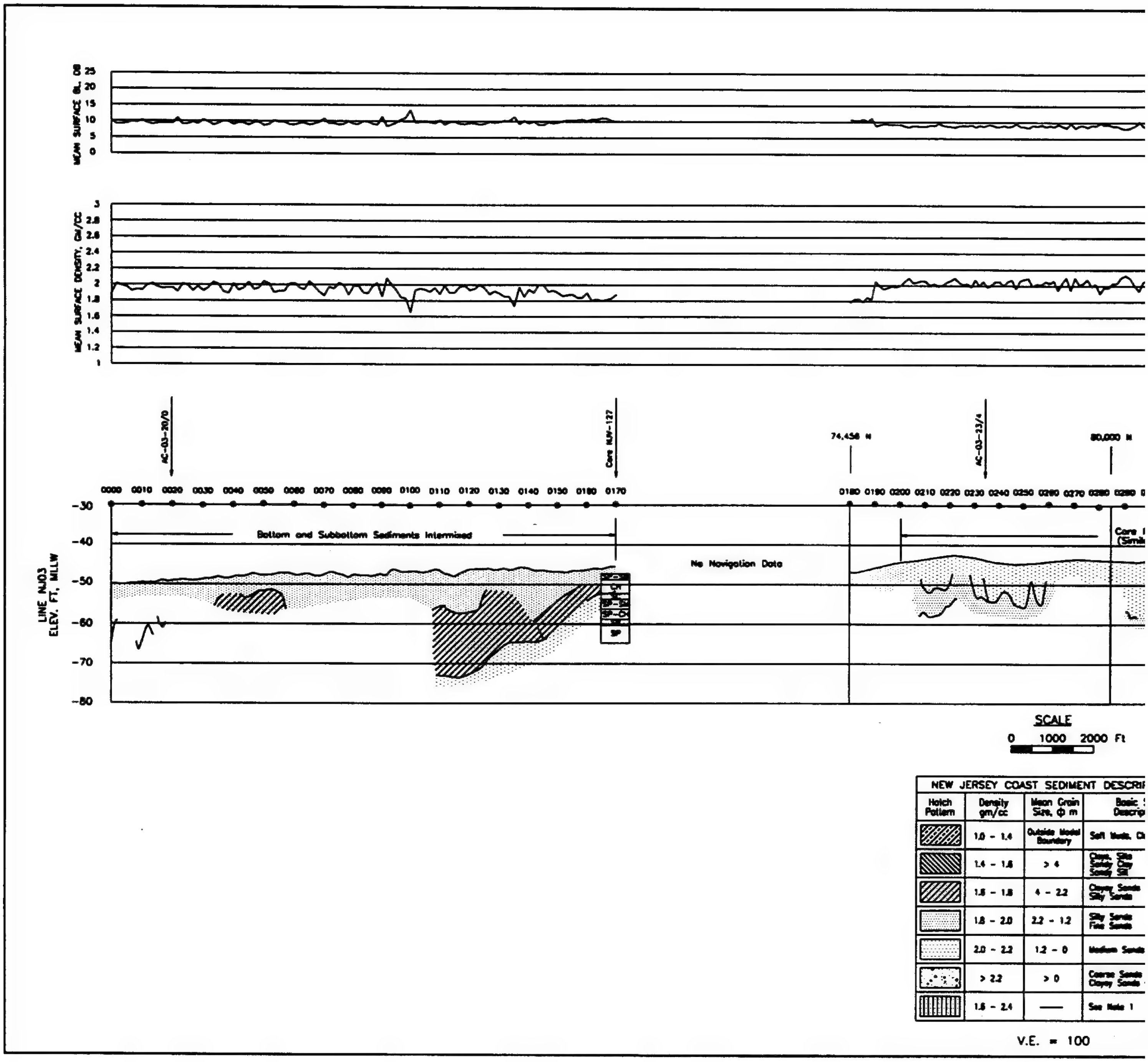
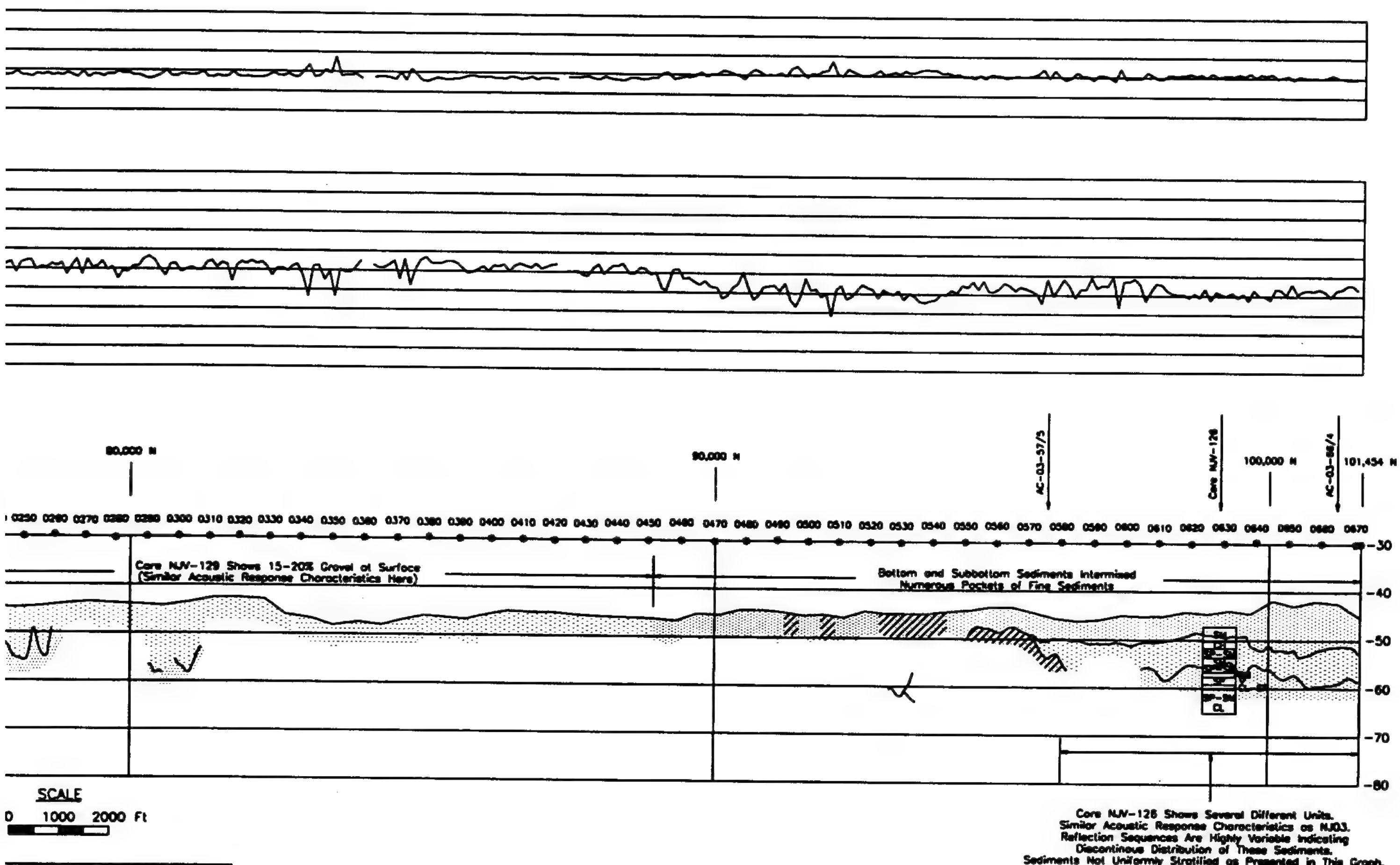
Plate 3


MEAN SURFACE BL, DB
MEAN SURFACE DENSITY, GM/CC
LINE NJ03
ELEV. FT, MLLW
AC-03-20/0
Core NJV-127
74,456 N
AC-03-23/4
80,000 N
Bottom and Subbottom Sediments Intermixed
No Navigation Data
SCALE
0 1000 2000 Ft
NEW JERSEY COAST SEDIMENT DESCRIP
Hatch Pattern
Density gm/cc
Mean Grain Size, φ m
1.0 - 1.4
Outside Model Boundary
1.4 - 1.6
> 4
1.6 - 1.8
4 - 2.2
1.8 - 2.0
2.2 - 1.2
2.0 - 2.2
1.2 - 0
> 2.2
> 0
1.6 - 2.4
See Note 1
V.E. = 100



SCALE

0 1000 2000 Ft

COAST SEDIMENT DESCRIPTION		
	Mean Grain Size, Φ m	Basic Soil Description
	Outside Model Boundary	Soft Muds, Clays
	> 4	Clays, Silts Sandy Clay Sandy Silt
	4 - 2.2	Clayey Sands Silty Sands
	2.2 - 1.2	Silty Sands Fine Sands
	1.2 - 0	Medium Sands
	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
	——	See Note 1

V.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ03

FILE NAME: NJ03.DWG

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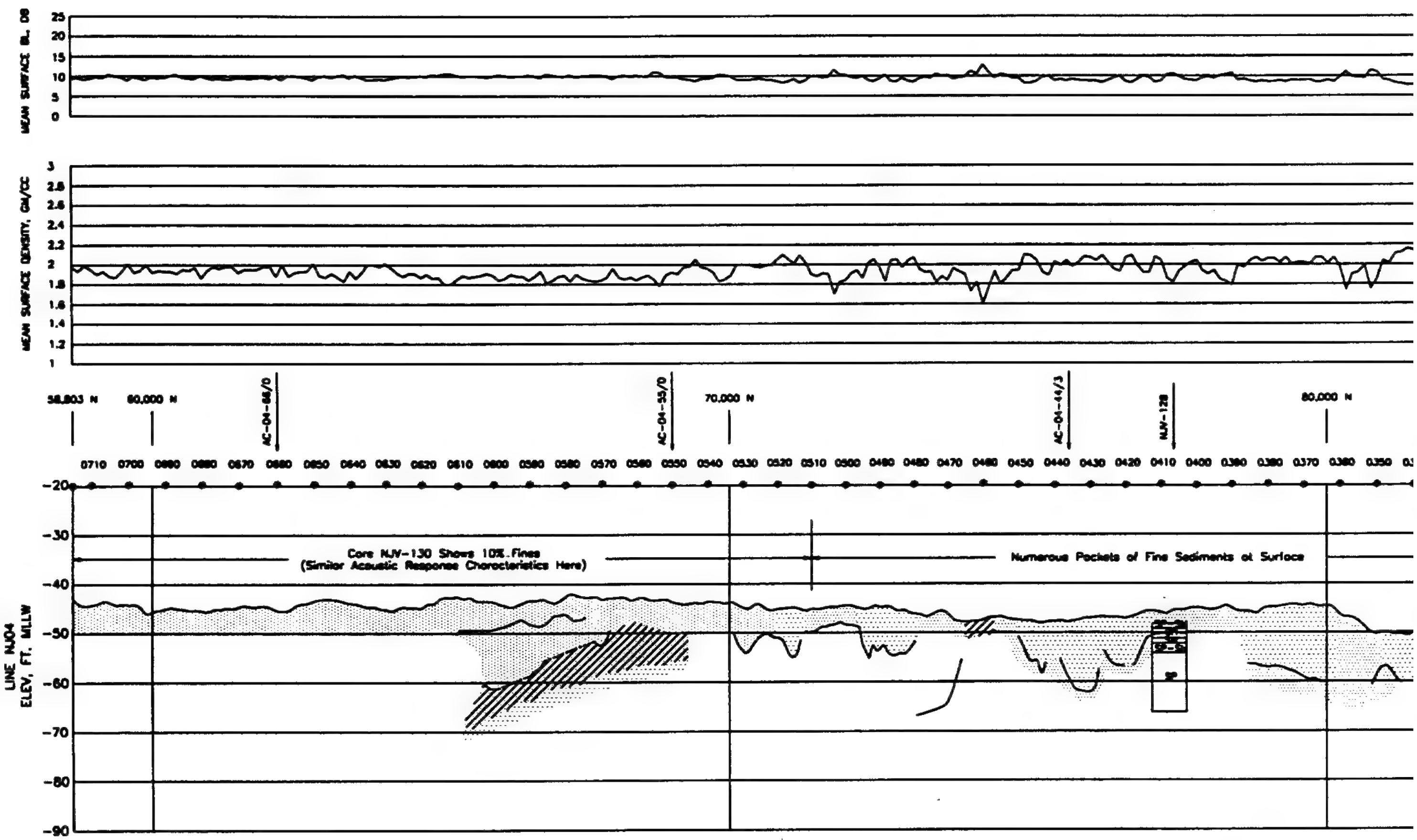
Plate 4

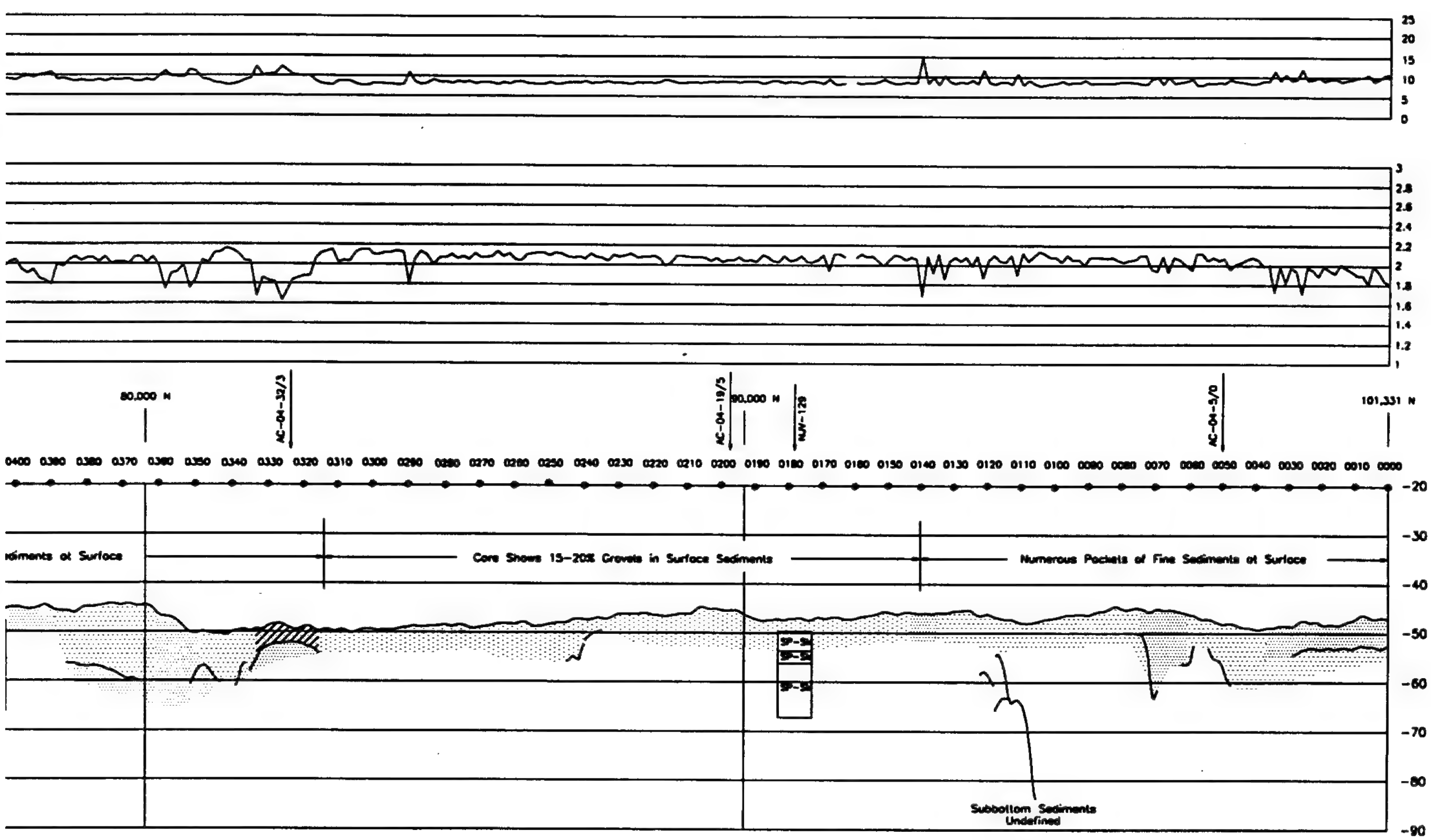


SCALE

0 1000 2000 Ft

NEW JERSEY COAST SEDIMENT DESCRIPTION			
Hatch Pattern	Density gm/cc	Mean Grain Size, φ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & Gr[illegible] Clayey Sands w/ Gr[illegible]
	1.6 - 2.4	——	See Note 1

V.E. = 100



SCALE

0 1000 2000 Ft

EY COAST SEDIMENT DESCRIPTION		
nsity n/cc	Mean Grain Size, Φ m	Basic Soil Description
- 1.4	Outside Model Boundary	Soft Muds, Clays
- 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
- 1.8	4 - 2.2	Clayey Sands Silty Sands
- 2.0	2.2 - 1.2	Silty Sands Fine Sands
- 2.2	1.2 - 0	Medium Sands
2.2	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
- 2.4	——	See Note 1

V.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ04

FILE NAME: NJ04.DWG

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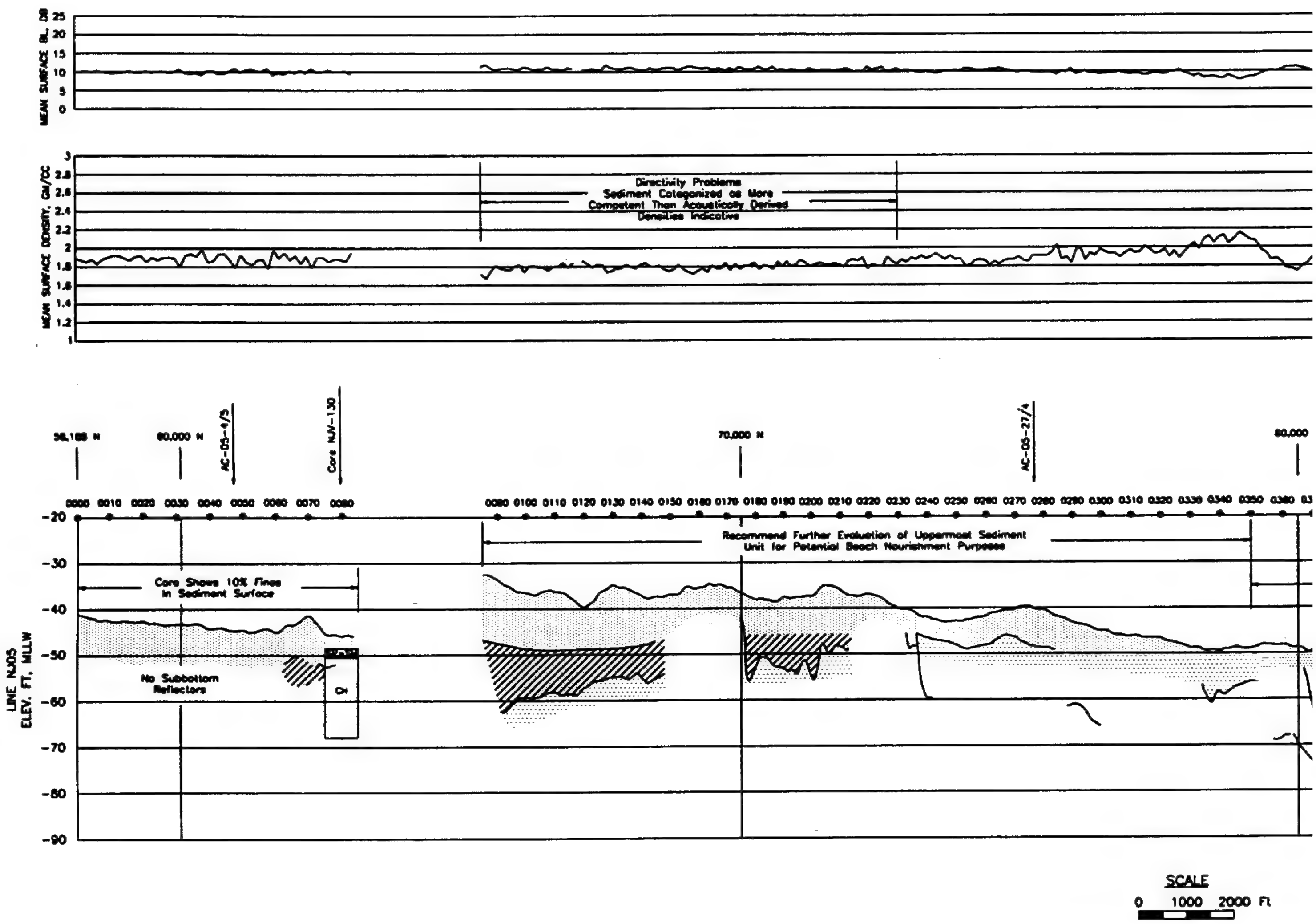
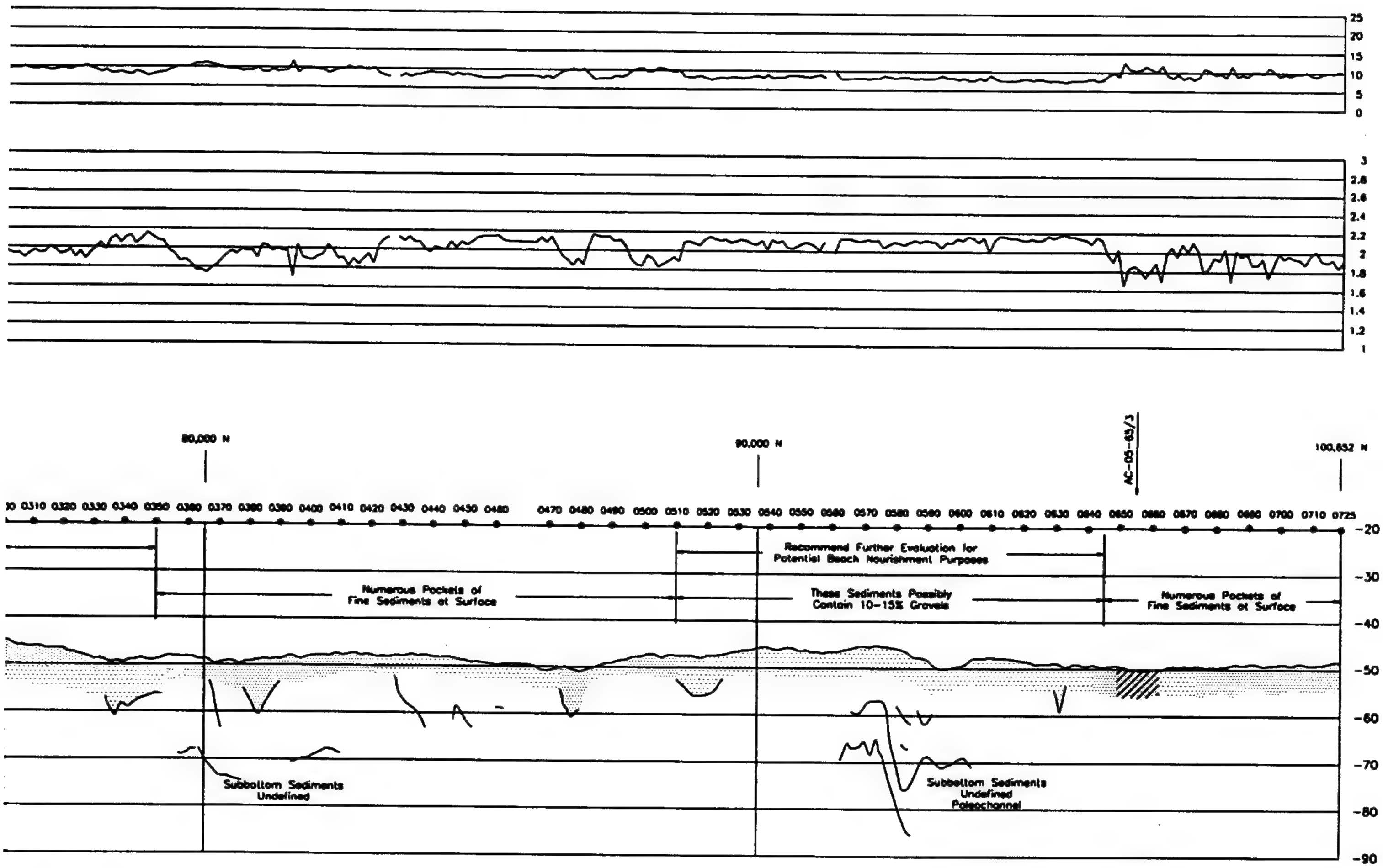


NEW JERSEY COAST SEDIMENT DESCRIPTIC			
Hatch Pattern	Density gm/cc	Mean Grain Size, ϕ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & (Clayey Sands w/
	1.6 - 2.4	——	See Note 1

V.E. = 100

Note 1: Sediments in this category consist of heterogenous distributions of sands, gravels, silts, and clays complexly distributed with little lateral or vertical continuity.



SCALE

0 1000 2000 Ft

ey Coast Sediment Description		
ensity m/cc	Mean Grain Size, ϕ m	Basic Soil Description
- 1.4	Outside Model Boundary	Soft Muds, Clays
- 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
- 1.8	4 - 2.2	Clayey Sands Silty Sands
- 2.0	2.2 - 1.2	Silty Sands Fine Sands
- 2.2	1.2 - 0	Medium Sands
> 2.2	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
6 - 2.4	——	See Note 1

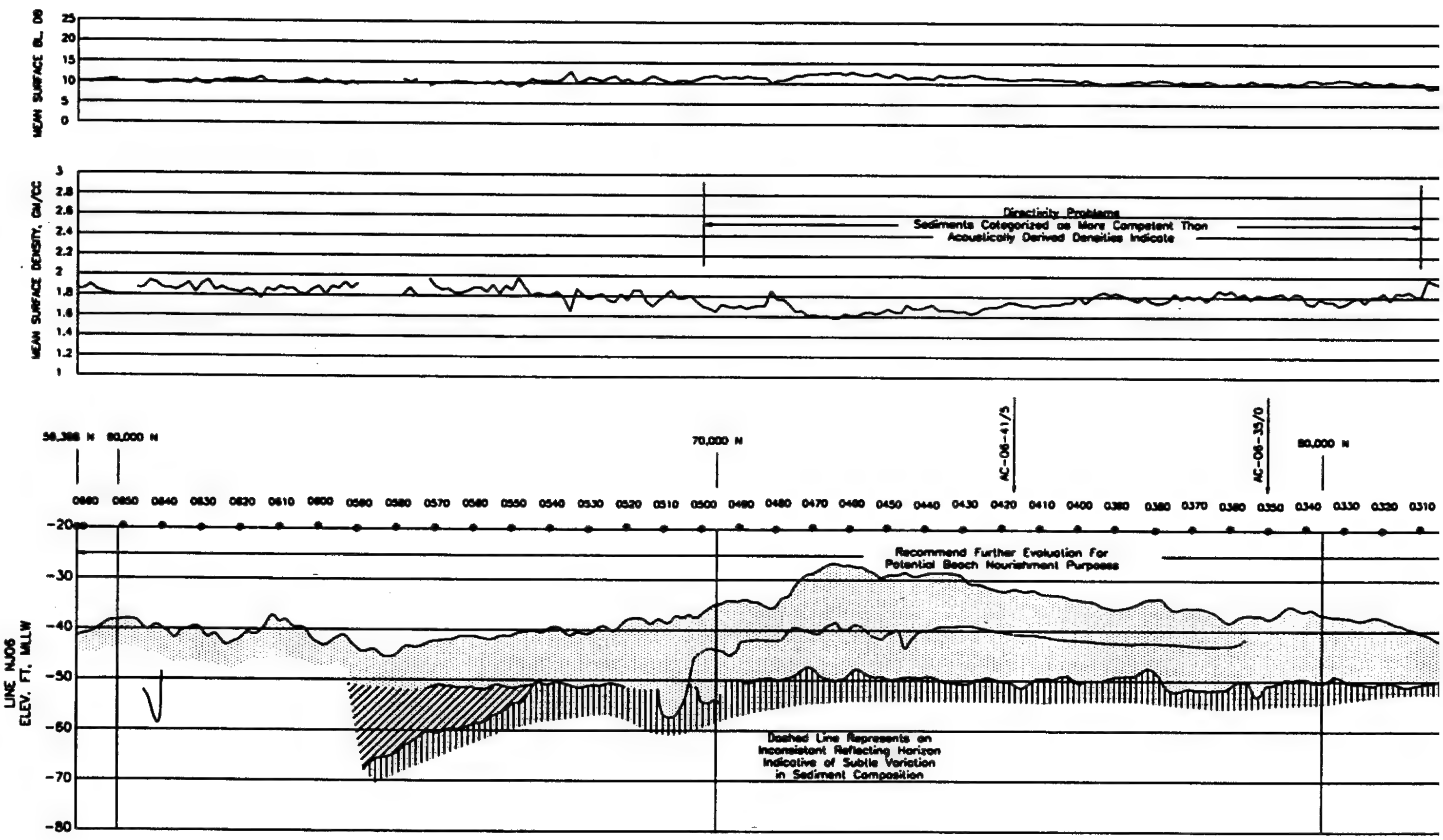
V.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ05

FILE NAME: NJ05.DWG

SCALE: AS NOTED | DATE: NOVEMBER 30, 1995 | SHEET



SCALE

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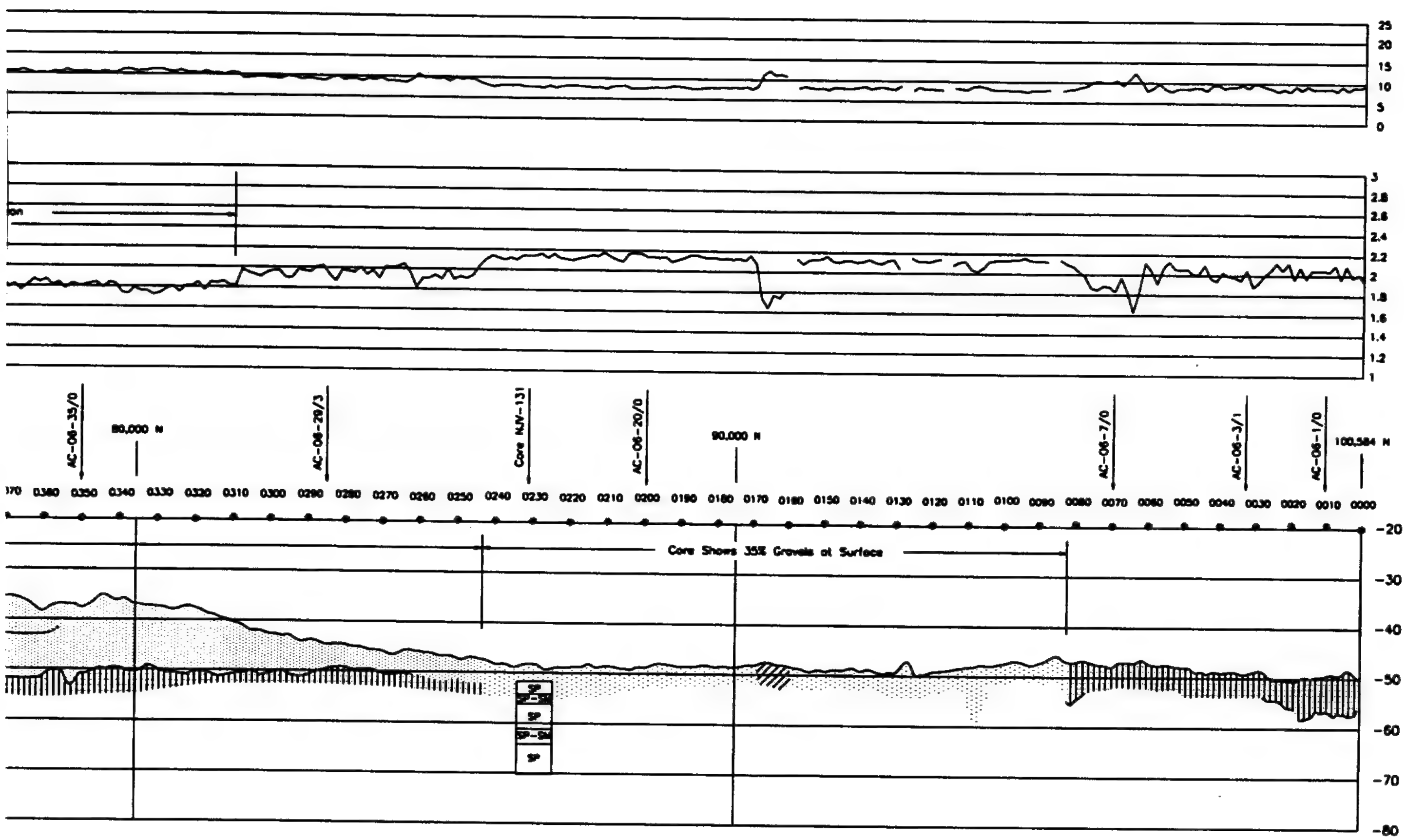
Note 1: Sediments in this category consist of heterogenous distributions of sands, gravels, silts, and clays complexly distributed with little lateral or vertical continuity.

NEW JERSEY COAST SEDIMENT DESCRIPTION			
Hatch Pattern	Density gm/cc	Mean Grain Size, Φ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & Grav[illegible] Clayey Sands w/ Grav[illegible]
	1.6 - 2.4	——	See Note 1

V.E. = 100



SCALE

0 1000 2000 Ft

EY COAST SEDIMENT DESCRIPTION		
ensity gm/cc	Mean Grain Size, Φ m	Basic Soil Description
- 1.4	Outside Model Boundary	Soft Muds, Clays
- 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
- 1.8	4 - 2.2	Clayey Sands Silty Sands
- 2.0	2.2 - 1.2	Silty Sands Fine Sands
- 2.2	1.2 - 0	Medium Sands
2.2	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
- 2.4	——	See Note 1

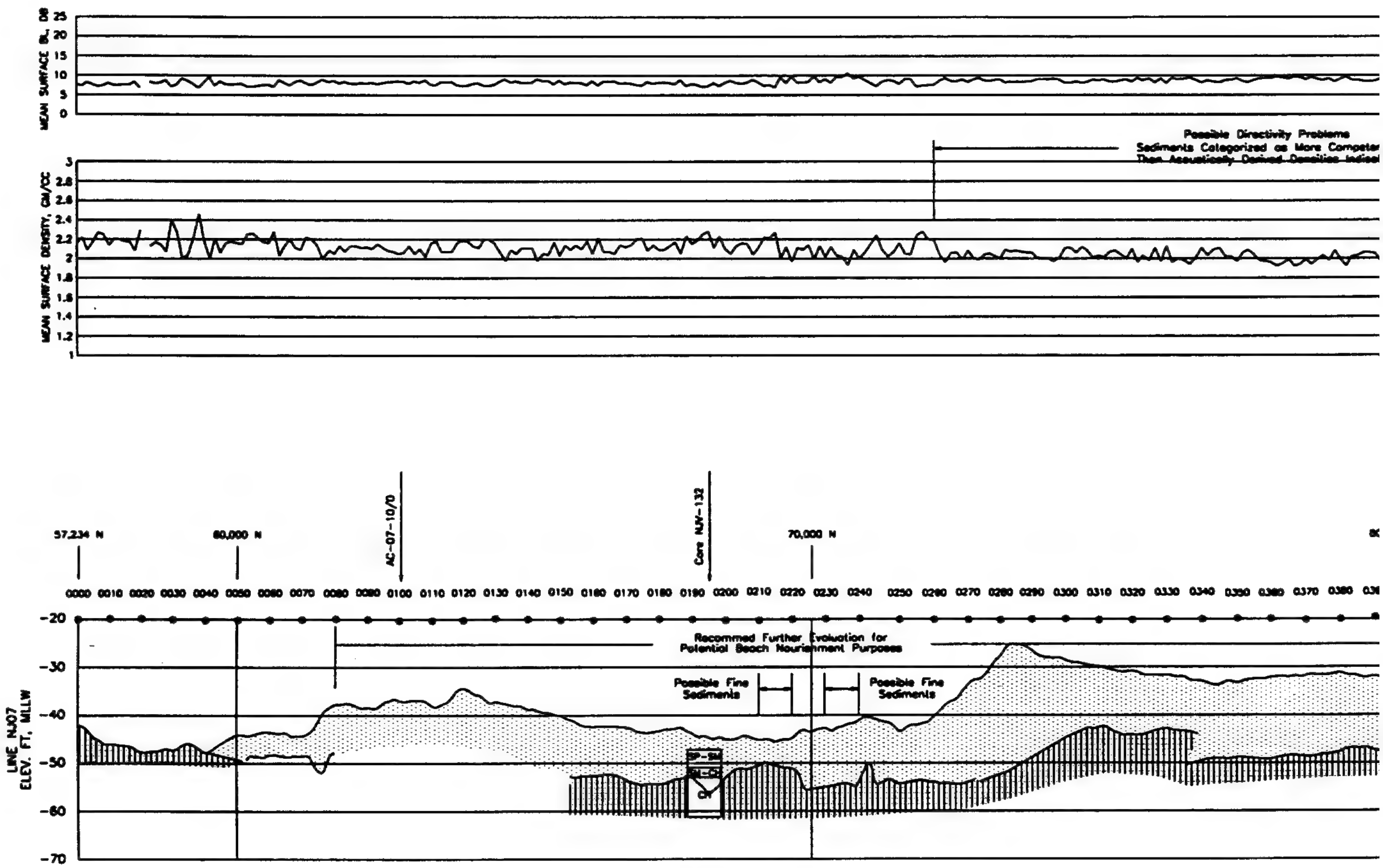
V.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ06

FILE NAME: NJ06.DWG
SCALE: AS NOTED | DATE: NOVEMBER 30, 1995 | SHEET

Plate 7



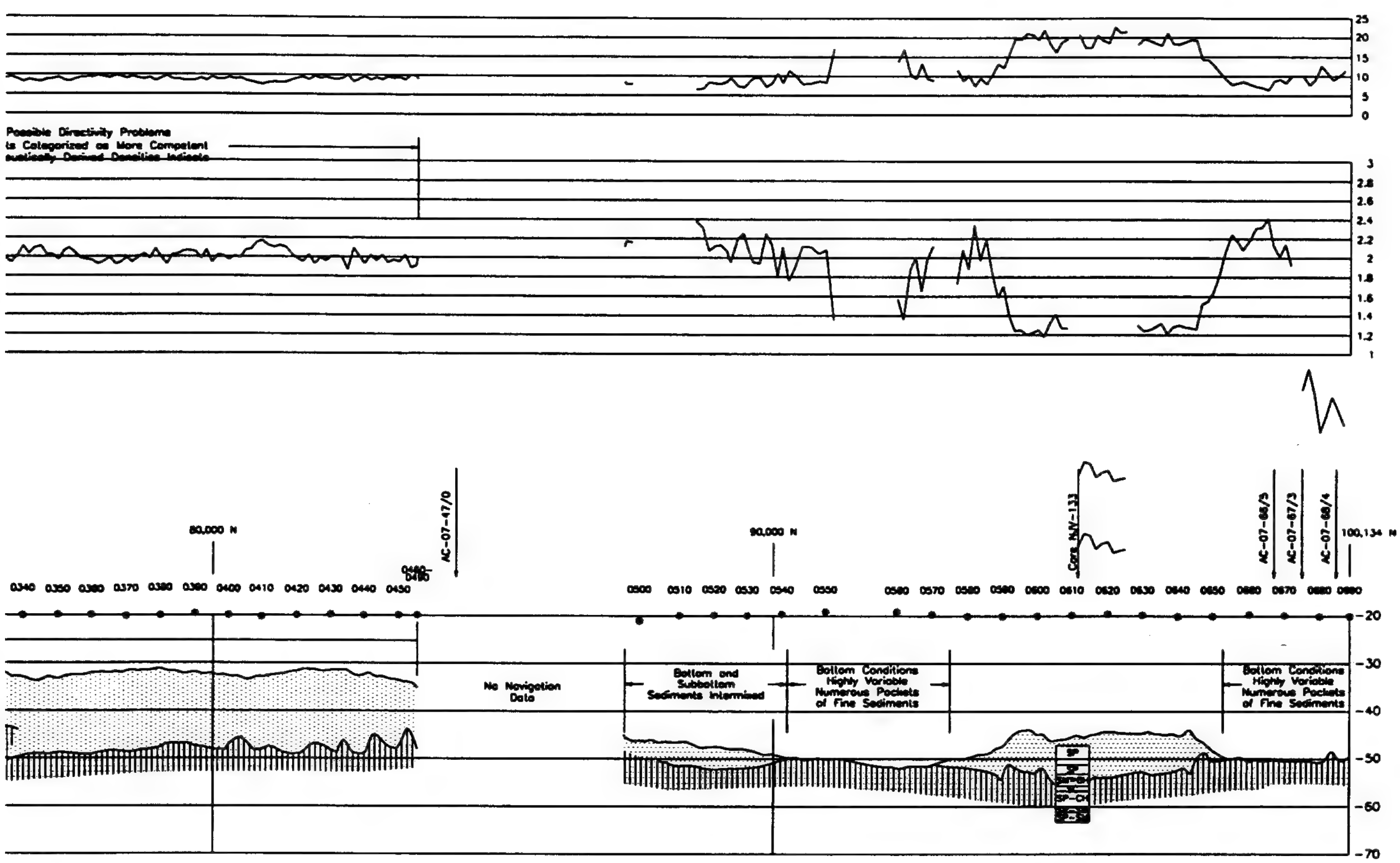
SCALE

0 1000 2000 Ft

NEW JERSEY COAST SEDIMENT DESCRIPTION			
Hatch Pattern	Density gm/cc	Mean Grain Size, ϕ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & Gr Clayey Sands w/ Gr
	1.6 - 2.4	——	See Note 1

V.E. = 100

Note 1: Sediments in this category consist of heterogenous distributions of sands, gravels, silts, and clays complexly distributed with little lateral or vertical continuity.



SCALE

0 1000 2000 Ft

COAST SEDIMENT DESCRIPTION		
	Mean Grain Size, Φ m	Basic Soil Description
4	Outside Model Boundary	Soft Muds, Clays
6	> 4	Clays, Silts Sandy Clay Sandy Silt
8	4 - 2.2	Clayey Sands Silty Sands
0	2.2 - 1.2	Silty Sands Fine Sands
2	1.2 - 0	Medium Sands
	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
4	——	See Note 1

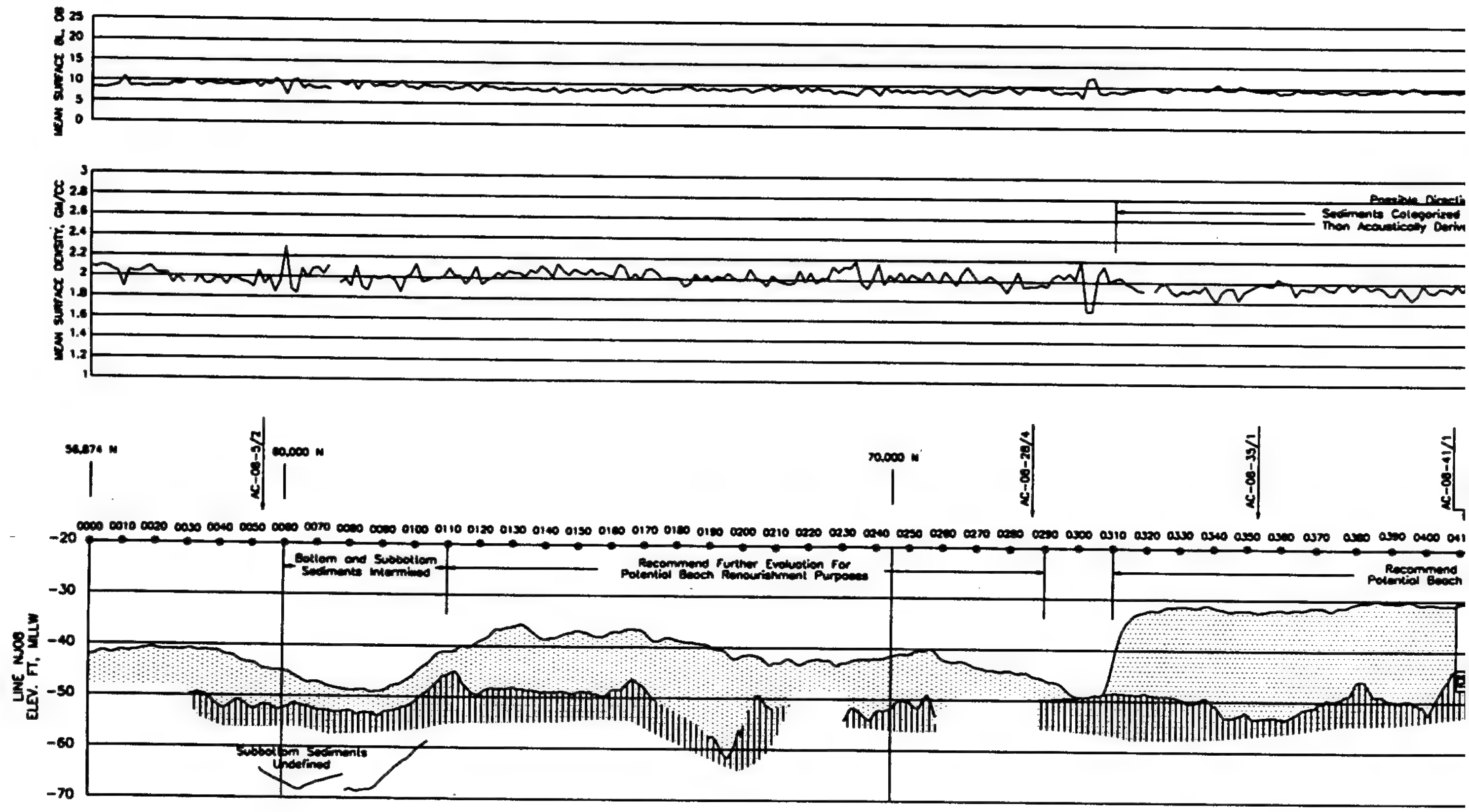
V.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ07

FILE NAME: NJ07.DWG

SCALE: AS NOTED | DATE: NOVEMBER 30, 1995 | SHEET



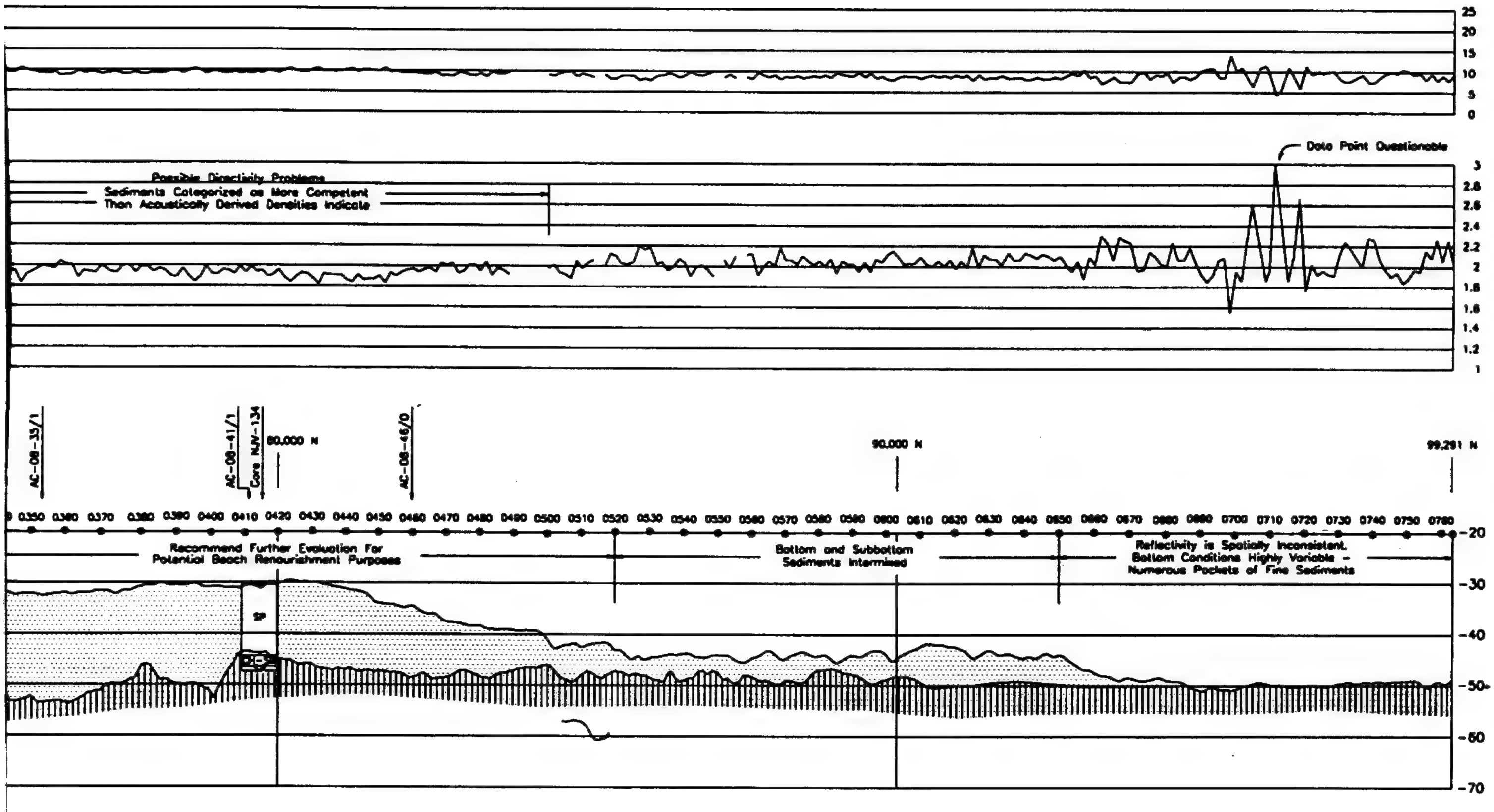
SCALE

0 1000 2000 Ft

NEW JERSEY COAST SEDIMENT DESCRIPTION			
Hatch Pattern	Density gm/cc	Mean Grain Size, φ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
	1.6 - 2.4	—	See Note 1

V.E. = 100

Note 1: Sediments in this category consist of heterogenous distributions of sands, gravels, silts, and clays complexly distributed with little lateral or vertical continuity.



SCALE

0 1000 2000 Ft

COAST SEDIMENT DESCRIPTION		
ity /cc	Mean Grain Size, Φ m	Basic Soil Description
1.4	Outside Model Boundary	Soft Muds, Clays
1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
1.8	4 - 2.2	Clayey Sands Silty Sands
2.0	2.2 - 1.2	Silty Sands Fine Sands
2.2	1.2 - 0	Medium Sands
2	> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
2.4	——	See Note 1

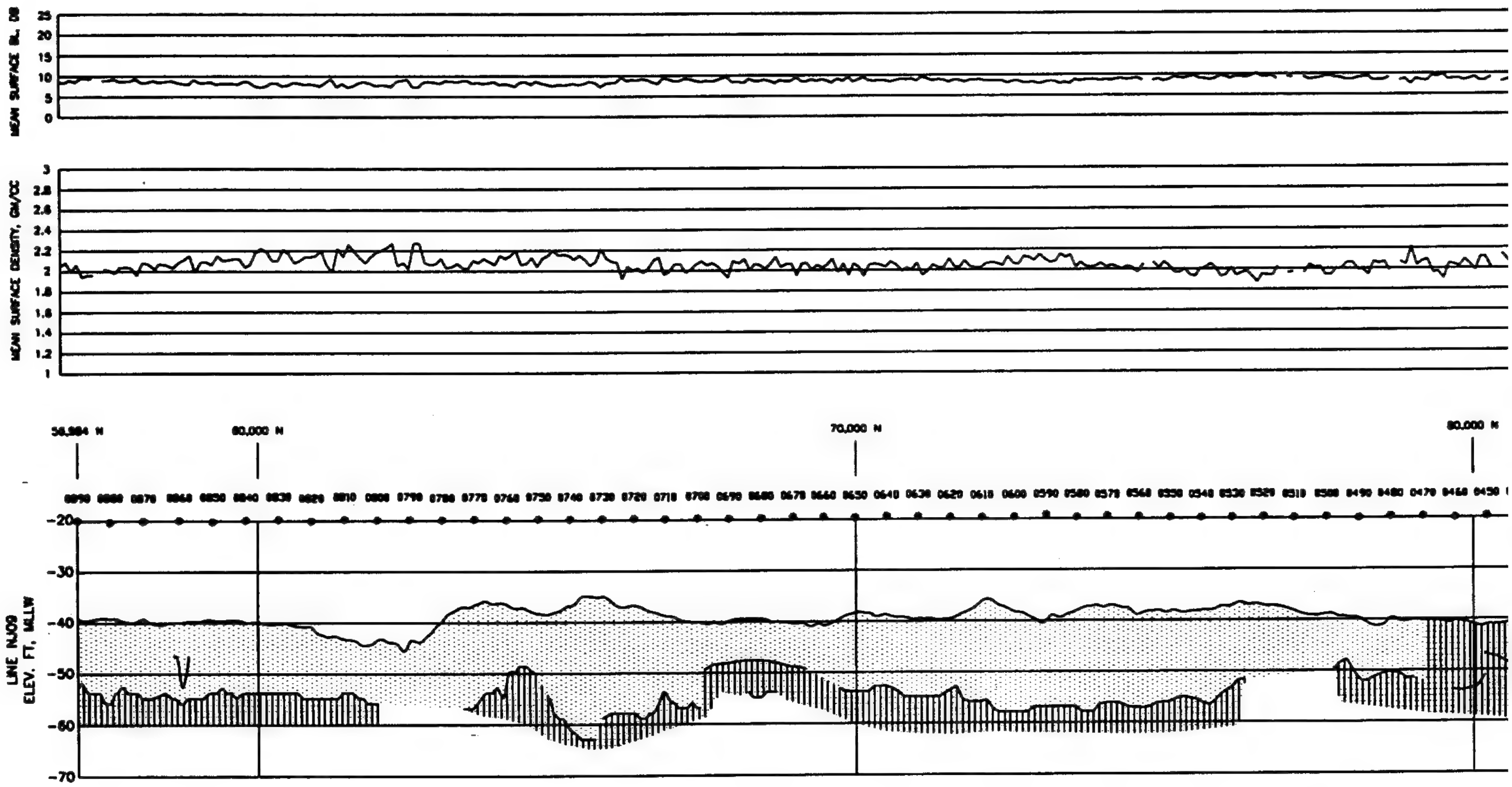
V.E. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ08

FILE NAME: NJ08.DWG

SCALE: AS NOTED | DATE: NOVEMBER 30, 1995 | SHEET



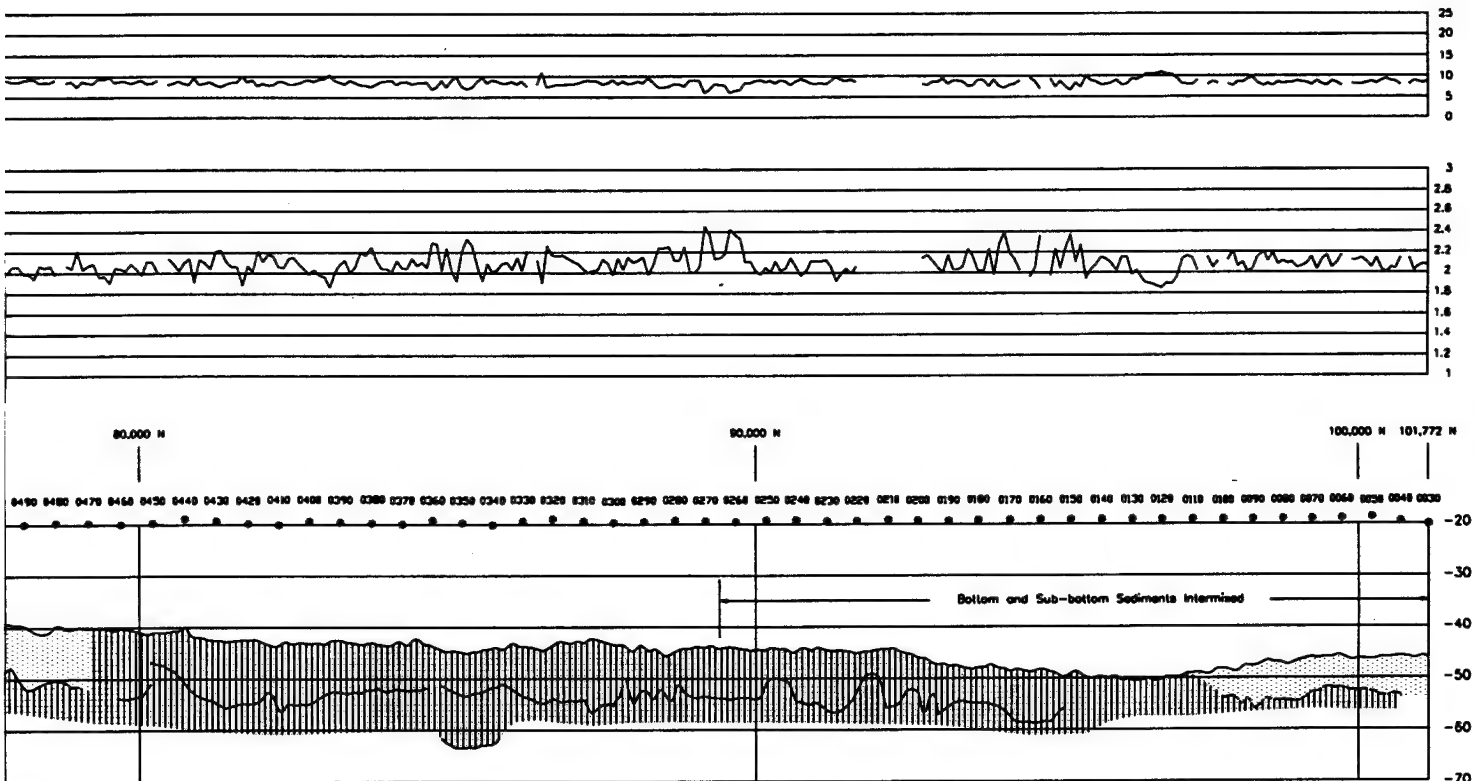
SCALE

0 1000 2000 Ft

Note 1: Sediments in this category consist of heterogenous distributions of sands, gravels, silts, and clays complexly distributed with little lateral or vertical continuity.

NEW JERSEY COAST SEDIMENT DESCRIPTIO			
Hatch Pattern	Density gm/cc	Mean Grain Size, Φ m	Basic Soil Description
	1.0 - 1.4	Outside Model Boundary	Soft Muds, Clays
	1.4 - 1.6	> 4	Clays, Silts Sandy Clay Sandy Silt
	1.6 - 1.8	4 - 2.2	Clayey Sands Silty Sands
	1.8 - 2.0	2.2 - 1.2	Silty Sands Fine Sands
	2.0 - 2.2	1.2 - 0	Medium Sands
	> 2.2	> 0	Coarse Sands & G Clayey Sands w/ C
	1.6 - 2.4	—	See Note 1

V.E. = 100



SCALE

1000 2000 Ft

T SEDIMENT DESCRIPTION	
lean Grain Size, φ m	Basic Soil Description
utside Model Boundary	Soft Muds, Clays
> 4	Clays, Silts Sandy Clay Sandy Silt
4 - 2.2	Clayey Sands Silty Sands
2.2 - 1.2	Silty Sands Fine Sands
1.2 - 0	Medium Sands
> 0	Coarse Sands & Gravels Clayey Sands w/ Gravels
——	See Note 1

t. = 100

WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
VICKSBURG, MS 39180

NEW JERSEY COAST
LINE NJ09

FILE NAME: NJ09.DWG

SCALE: AS NOTED | DATE: NOVEMBER 30, 1995 | SHEET

Plate 10

Appendix A
New Jersey Coast Sediment Data

This appendix presents the physical sample data used during analysis of the geoacoustic data from the New Jersey coast. The data include the drilling logs and sediment gradation analysis. The core data are ordered in this appendix according to Table 1 in the text.

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

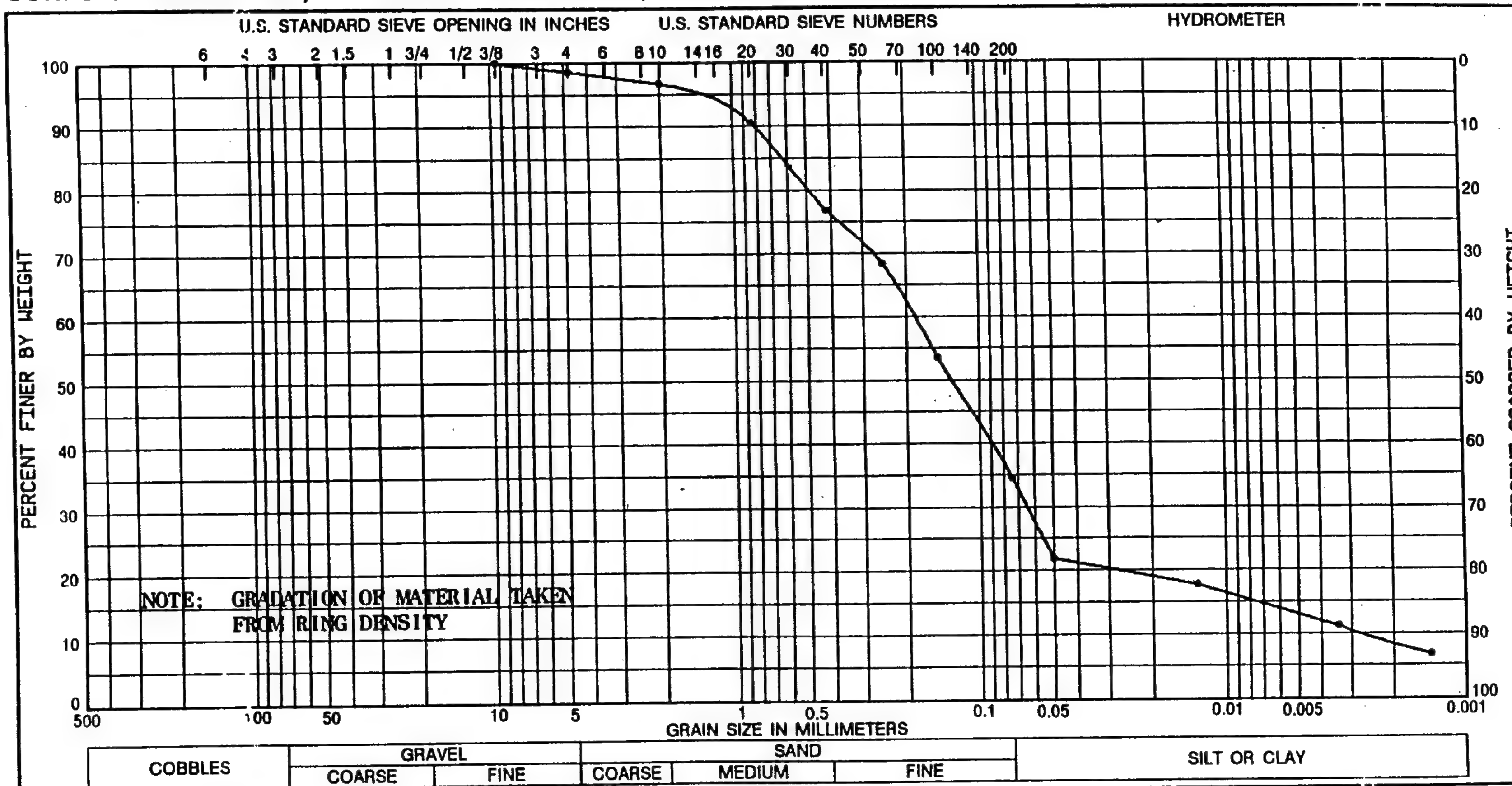
Project: *VIBRACORE SEDIMENT SAMPLES*	Boring No. *NJV-123*
Location: *OFFSHORE OF NEW JERSEY*	Lab No. *184/850*
Boring Depth (ft): *16.50* — Elevation: ——	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*	Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0–4		GRAY, SILTY SAND (SM).	A -3.2/-3.6' WET DEN. = 118.8, DRY DEN. = 93.3, M. C. = 27.3%
	4–5		GRAY, CLAYEY SAND (SC).	MA -4.8/-5.2'
-5	5–7		GRAY, LEAN CLAY (CL).	
	7–9.5		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH POCKETS OF ORGANIC MATTER AT 9.2 -9.6'.	B -7.3/-7.7' WET DEN. = 119.7, DRY DEN. = 98.4, M. C. = 21.6%
-10	9.5–16.5		TAN AND GRAY, POORLY GRADED SAND (SP), WITH A POCKET OF GRAVELY (SP) AT 12.0 -12.7".	C -10.4/-10.8' WET DEN. = 104.7, DRY DEN. = 70.1, M. C. 49.4%
-15				D -15.0/-15.4 WET DEN. = 135.9, DRY DEN. = 121.0, M. C. = 12.3%

Date: *04/18/94* LABORATORY LOG AND SAMPLE DATUM Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



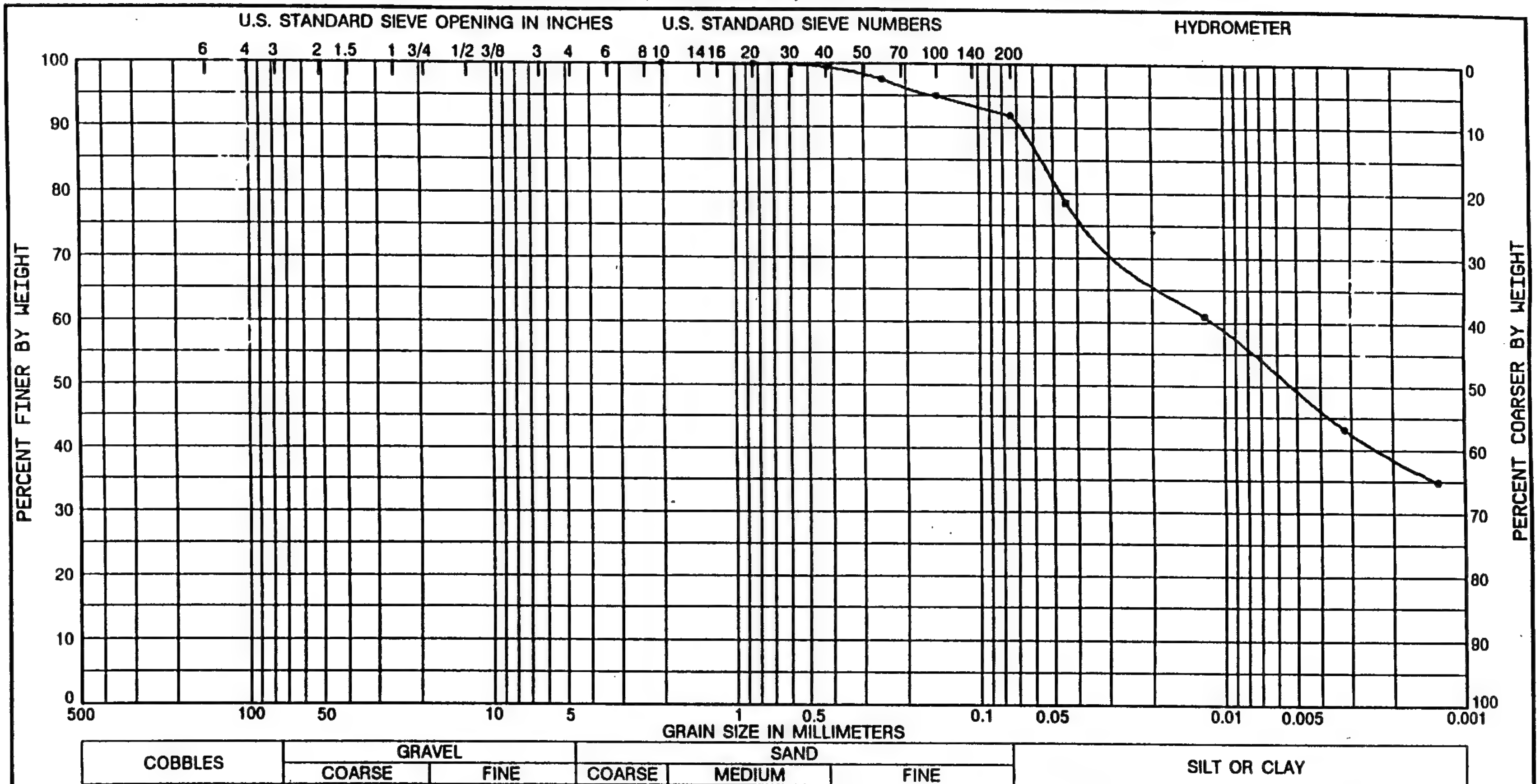
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-3.2 / -3.6'	(VISUAL) GRAY, CLAYEY SAND (SC), WITH	27.3			
		A TRACE OF GRAVEL SIZES AND MICA				
		SP. GRAVITY = 2.69				
		WET DENSITY = 118.8 PCF.				
		DRY DENSITY = 93.3 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/850A
Boring No. NJV-123
Date 04/08/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 4.8 / - 5.2'	(VISUAL) GRAY, LEAN CLAY (CL), WITH A TRACE OF SAND SIZES AND MICA.				

Project VIBRACORE SEDIMENT SAMPLES OFFSHORE OF NEW JERSEY

Lab No. 184/850

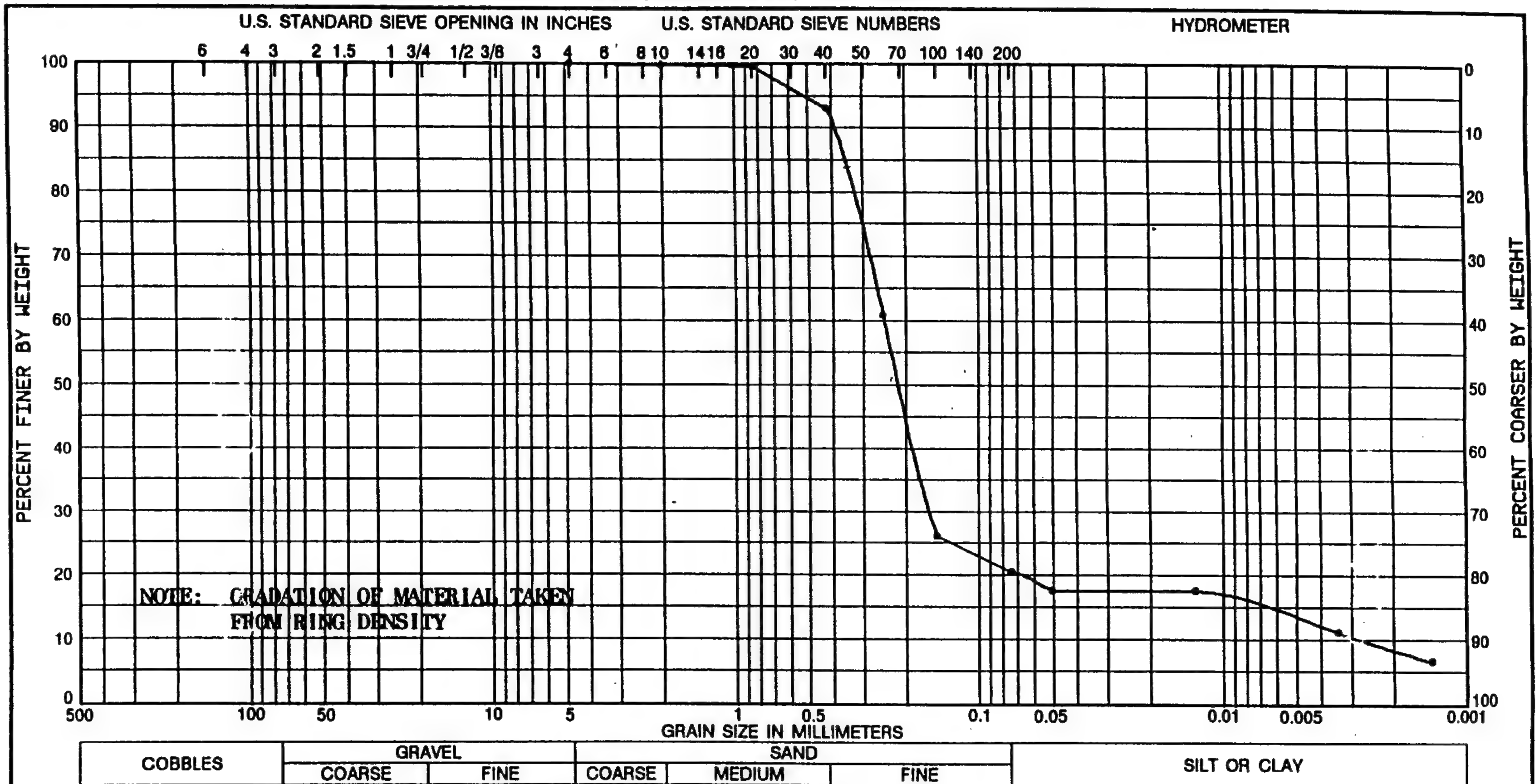
Boring No. NJV-123

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



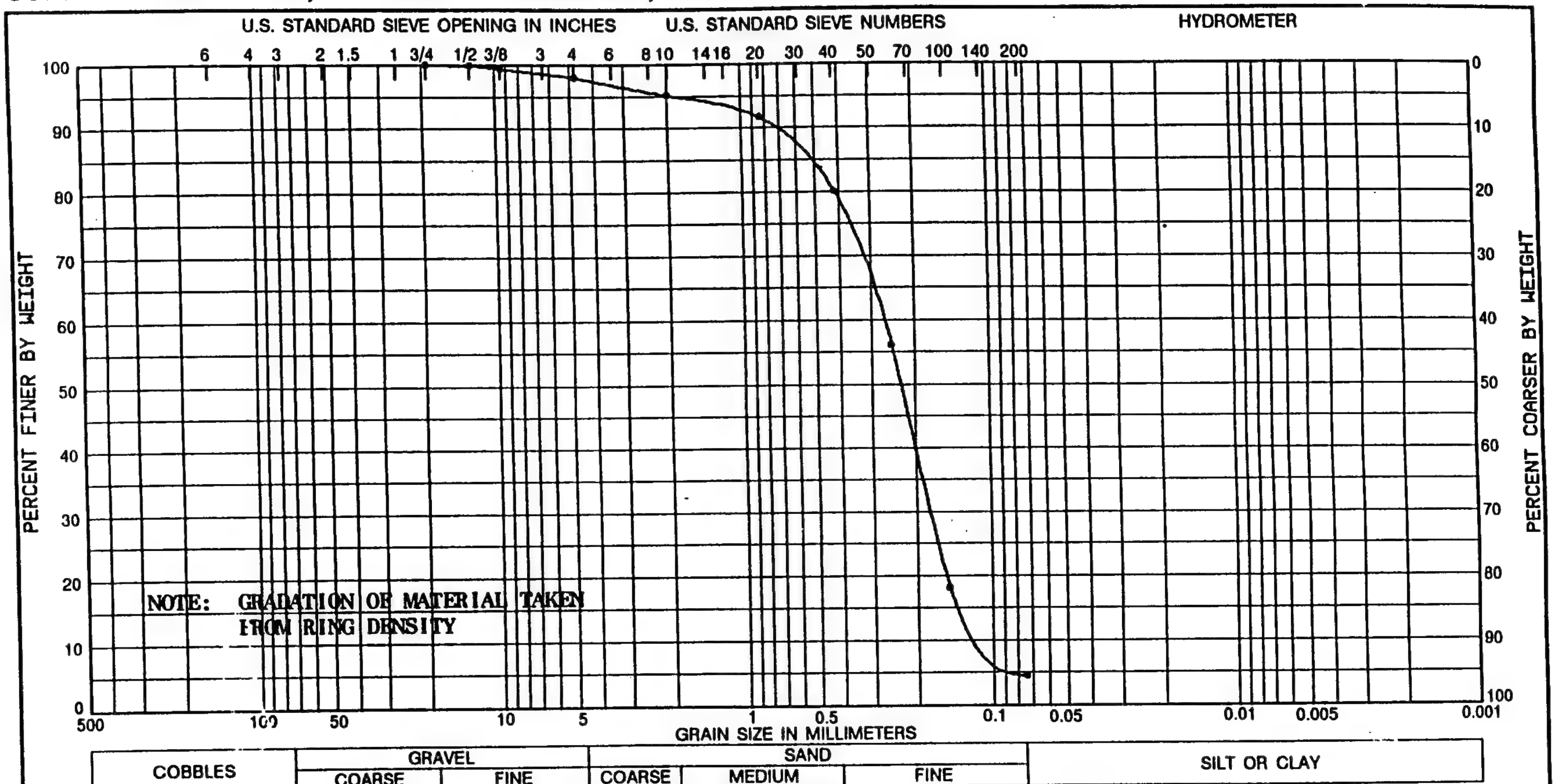
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-7.3 / -7.7'	(VISUAL) GRAY, SILTY SAND (SM), WITH	21.6			
		PLASTIC FINES.				
		SP. GRAVITY = 2.67				
		WET DENSITY = 119.7 PCF.				
		DRY DENSITY = 98.4 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/850B
Boring No. NJV-123
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612

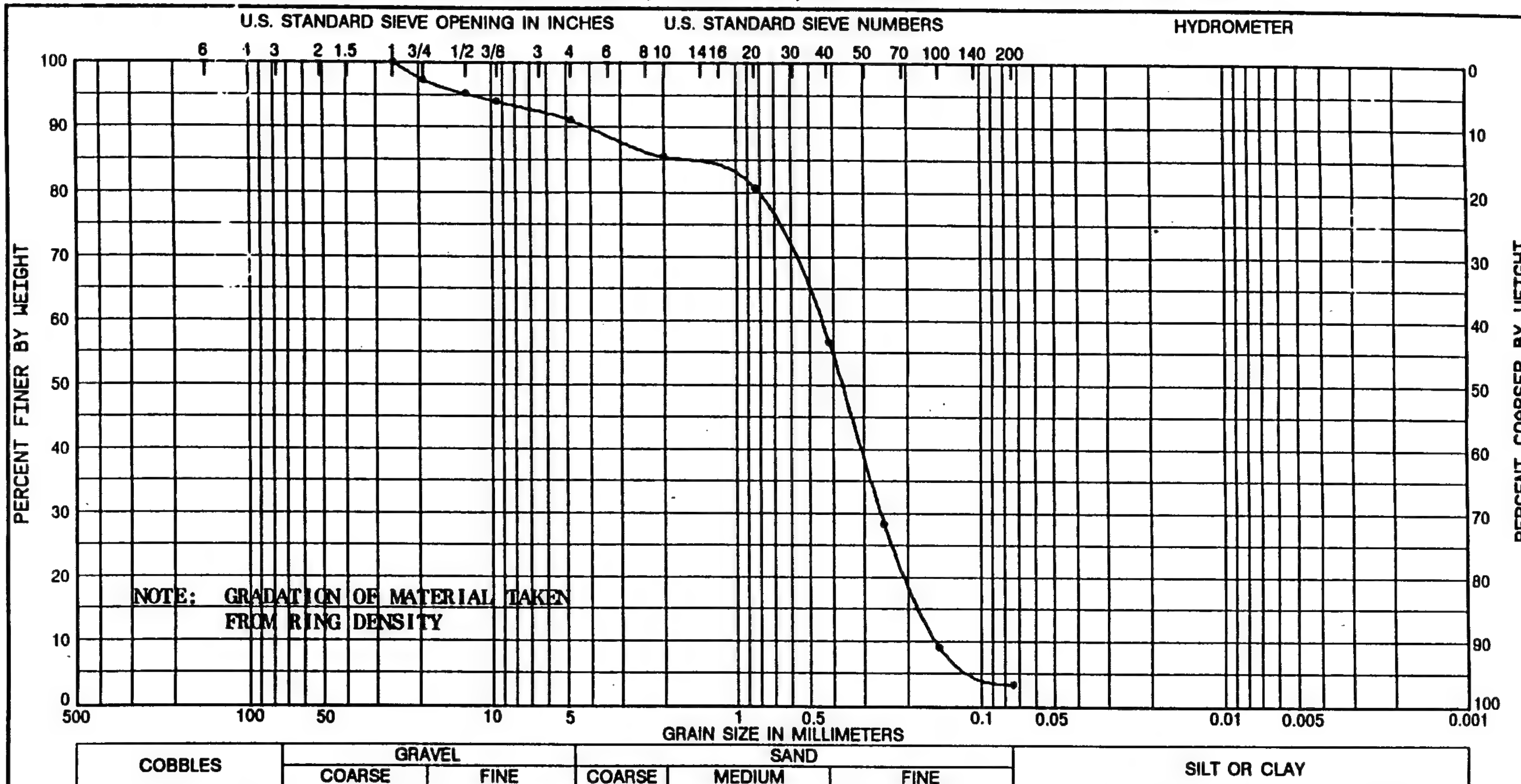


Piece No.	Elev.	Classification	Nat w%	LL	PL	PI	
3	-10.4 / -10.8'	(VISUAL) GRAY, POORLY GRADED SAND (SP),	49.4				Project VIBRACORE SEDIMENT SAMPLES
		WITH A TRACE OF GRAVEL SIZES AND ORGANICS.					OFFSHORE OF NEW JERSEY
		SP. GRAVITY = 2.64					Lab No. 184/850C
		WET DENSITY = 104.7 PCF.					Boring No. NJV-123
		DRY DENSITY = 70.1 PCF.					Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-15.0 / -15.4'	(VISUAL) TAN POORLY GRADED SAND (SP),	12.3			
		WITH A TRACE OF GRAVEL SIZES.				
		SP. GRAVITY = 2.68				
		WET DENSITY = 135.9 PCF.				
		DRY DENSITY = 121.0 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/850D
Boring No. NJV-123
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

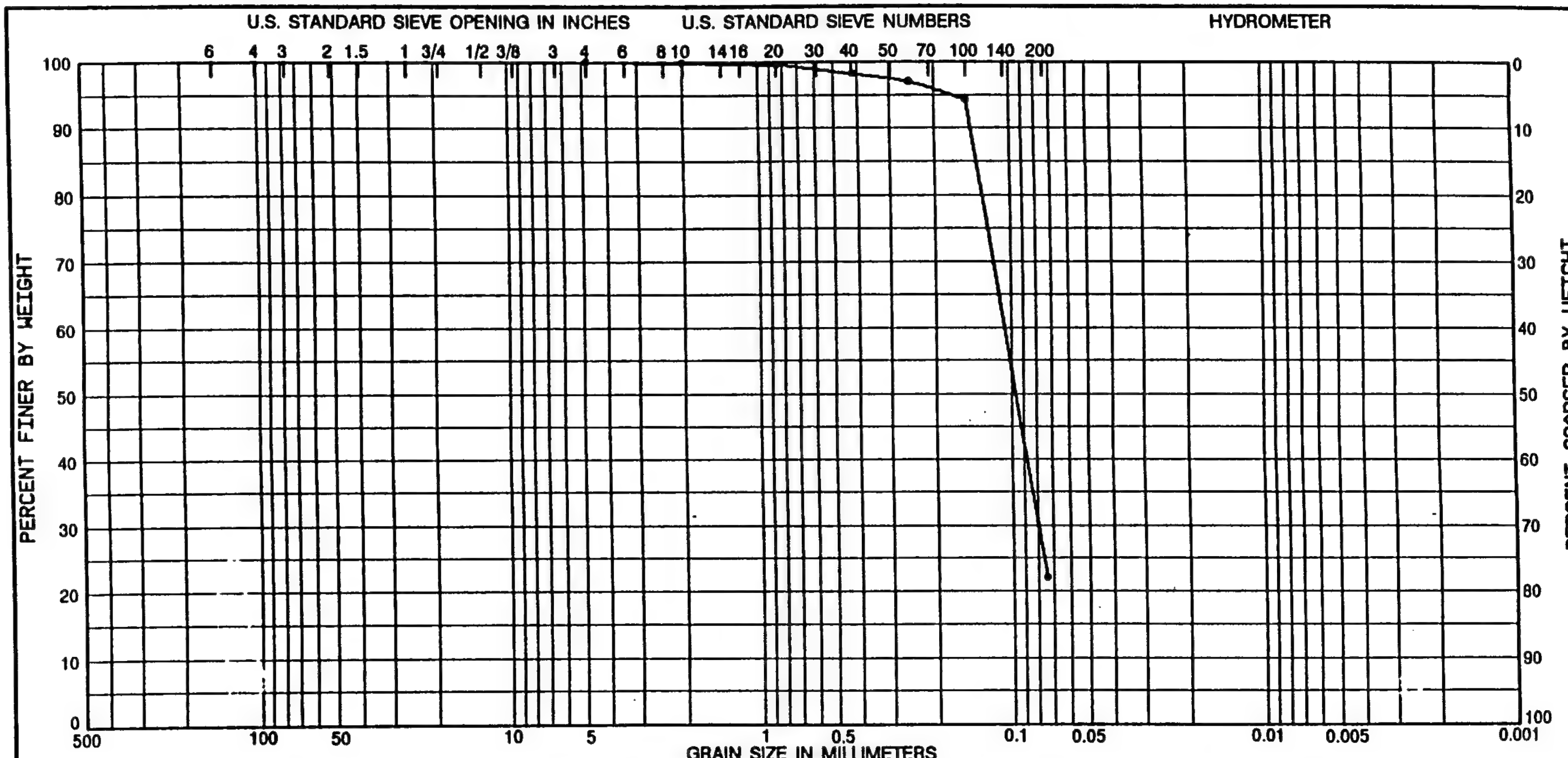
Project: *VIBRACORE SEDIMENT SAMPLES*	Boring No. *NJV-124*
Location: *OFFSHORE OF NEW JERSEY*	Lab No. *184/851*
Boring Depth (ft): *17.00* — Elevation: ———	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*	Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0				
	1			SA -1.0/-1.3'
	2		GRAY, SILTY SAND (SM).	
	3			A -3.0/-3.4' WET DEN. = 125.6, DRY DEN. = 102.8, M. C. = 22.2%
	4		GRAY, SILTY SAND (SM), WITH SOME GRAVEL SIZES.	
-5	5			
	6		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH OCCASIONAL POCKETS OF (SP).	
	7			
	8		GRAY, SANDY LEAN CLAY (CL), WITH A TRACE OF MICA.	B -8.0/-8.5' WET DEN. = 124.9, DRY DEN. = 105.2, M. C. = 18.7%
	9			
-10	10		GRAY, ALTERNATE LAYERS AND POCKETS OF LEAN CLAY (CL) AND POORLY GRADED SAND (SP).	
	11			
	12			
	13		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA.	C -13.0/-13.4' WET DEN. = 117.8, DRY DEN. = 105.1, M. C.=12.0%
	14			
-15	15			
	16		GRAY, LEAN CLAY (CL), WITH POCKETS AND LAYERS OF POORLY GRADED SAND (SP).	D -16.0/-16.4' WET DEN. = 121.1, DRY DEN. = 102.3, M. C.=20.3%
	17			

Date: *04/18/94* LABORATORY LOG AND SAMPLE DATUM Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

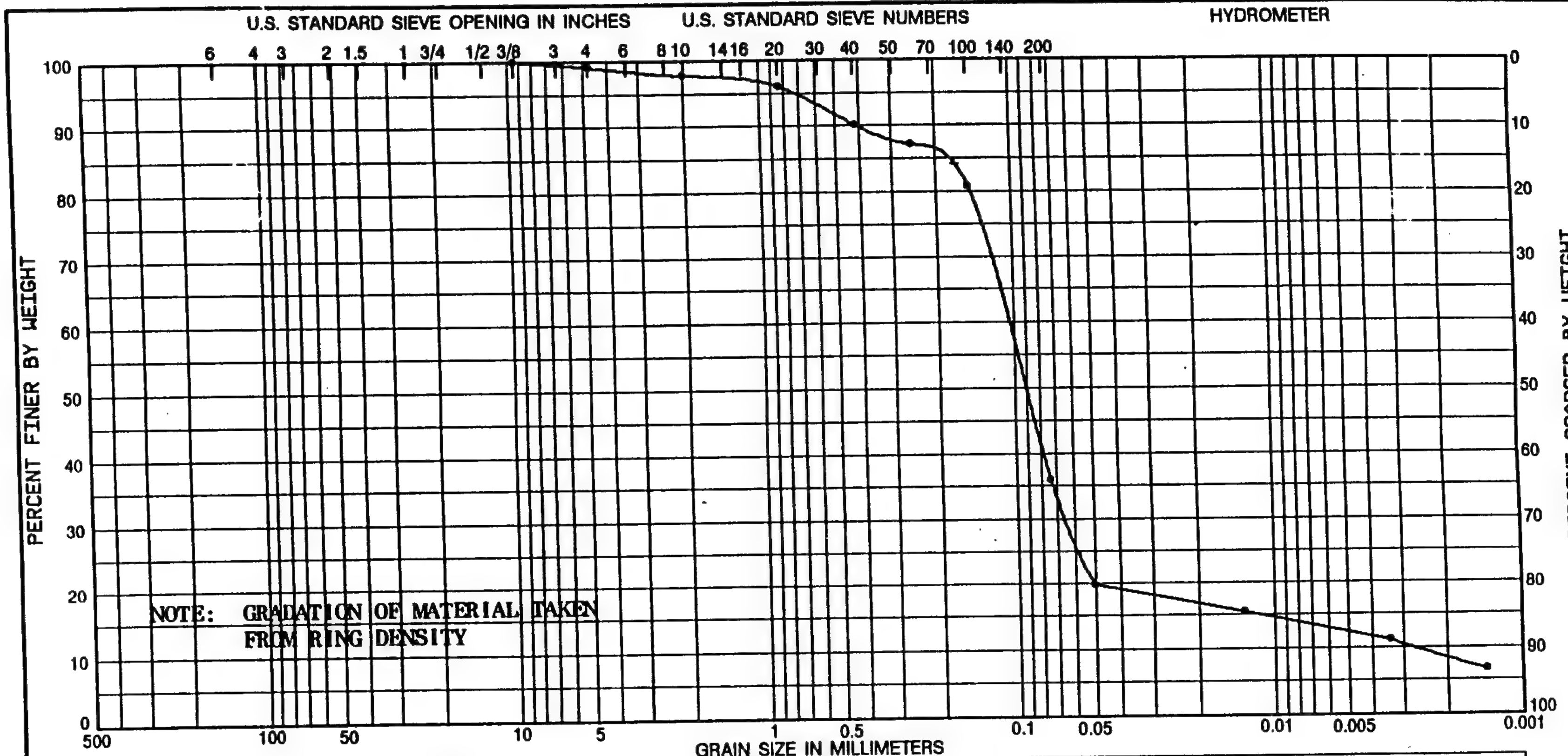
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	- 1.0 / - 1.3'	(VISUAL) GRAY SILTY SAND (SM).				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/851
Boring No. NJV-124
Date 04/15/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-3.0 / -3.4'	(VISUAL) GRAY, SILTY SAND (SM), WITH PLASTIC FINES AND A TRACE OF MICA.	22.2			
		SP. GRAVITY = 2.71				
		WET DENSITY = 125.6 PCF.				
		DRY DENSITY = 102.8 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/851A

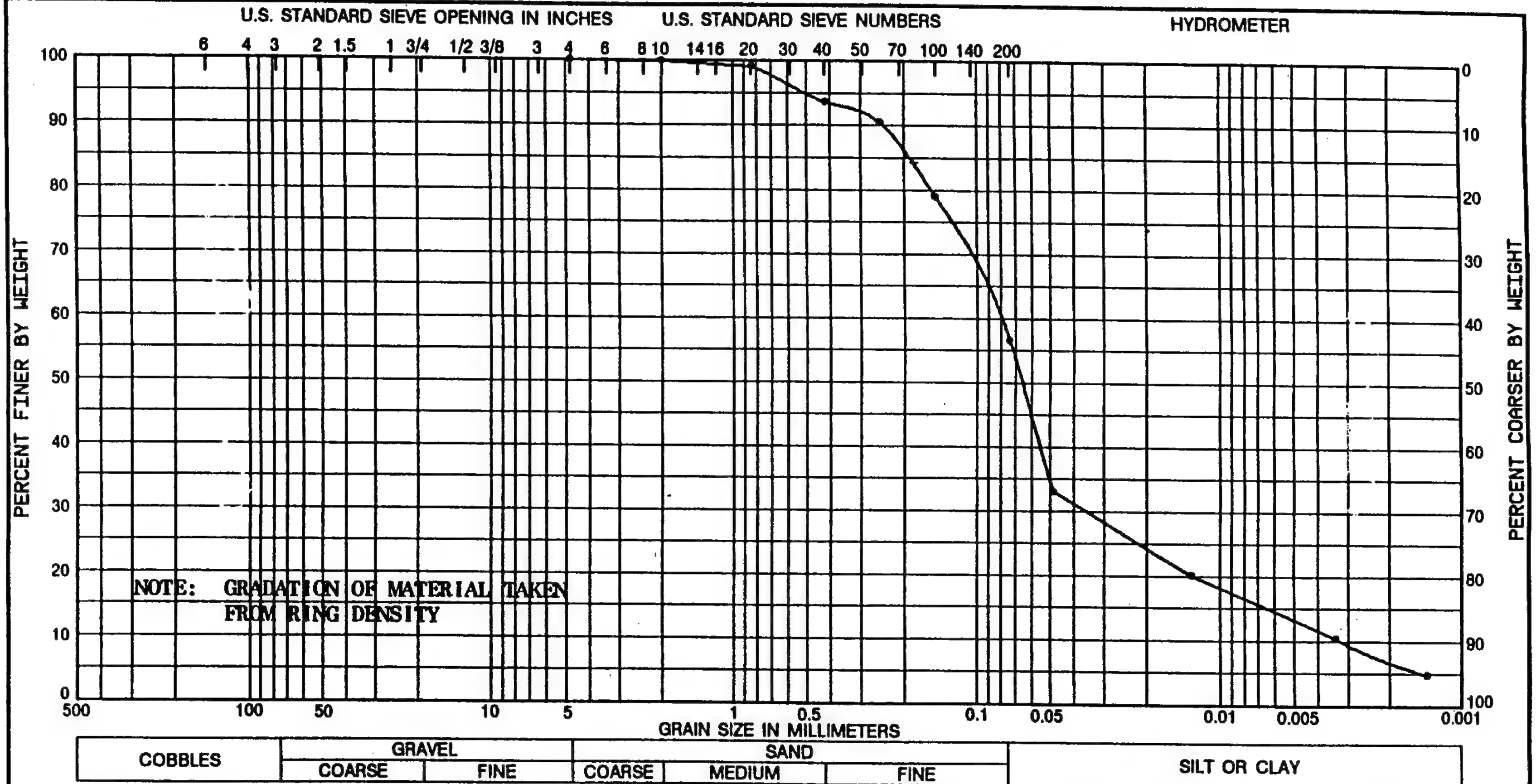
Boring No. NJV-124

Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



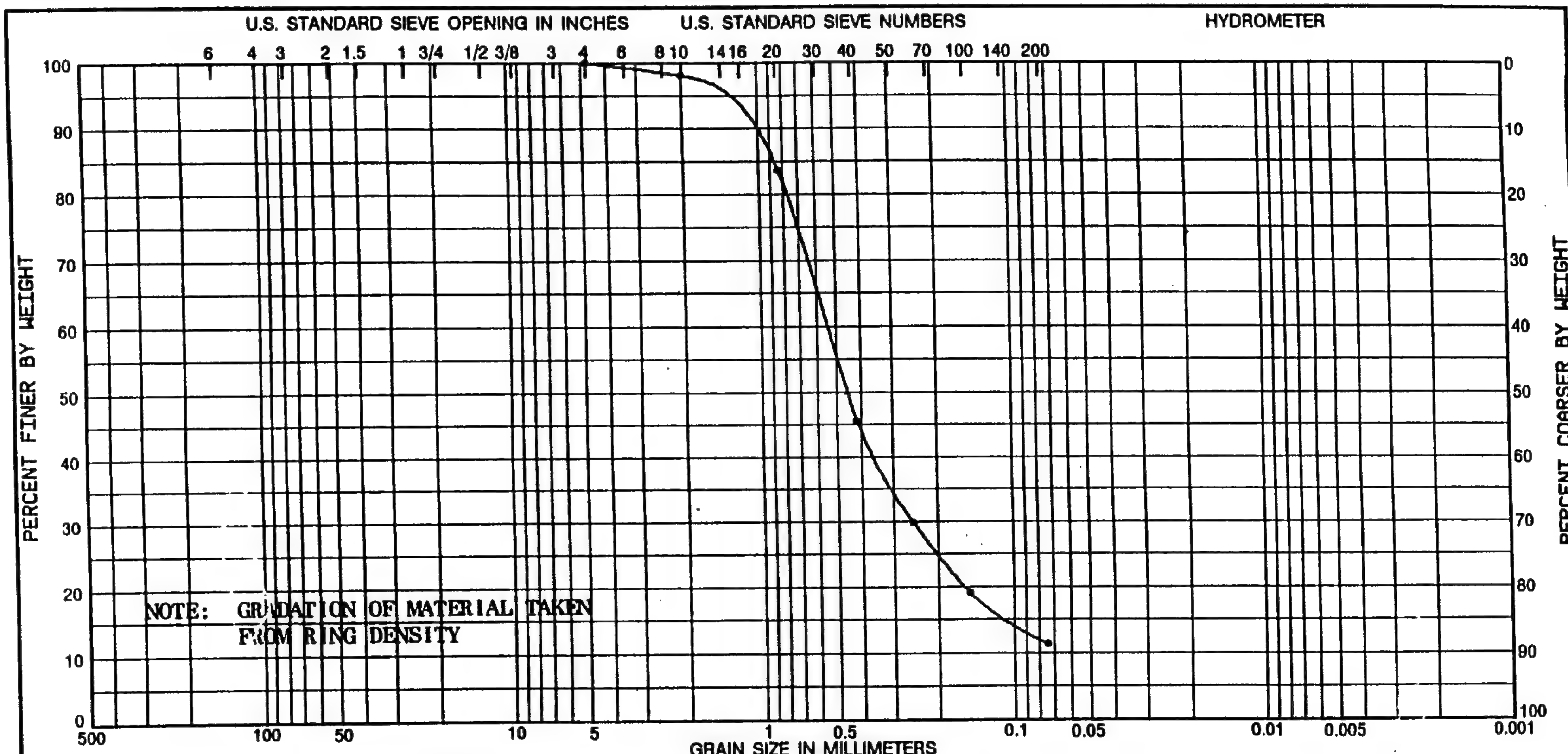
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-8.0 / -8.5'	(VISUAL) GRAY, SANDY LEAN CLAY (CL),	18.7			
		WITH A TRACE OF MICA.				
		SP. GRAVITY = 2.68				
		WET DENSITY = 124.9 PCF.				
		DRY DENSITY = 105.2 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/851B
Boring No. NJV-124
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-13.0 / -13.4'	(VISUAL) GRAY, POORLY GRADED SILTY SAND	12.0			
		(SP-SM), WITH A TRACE OF MICA.				
		SP. GRAVITY = 2.69				
		WET DENSITY = 117.8 PCF.				
		DRY DENSITY = 105.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/851C

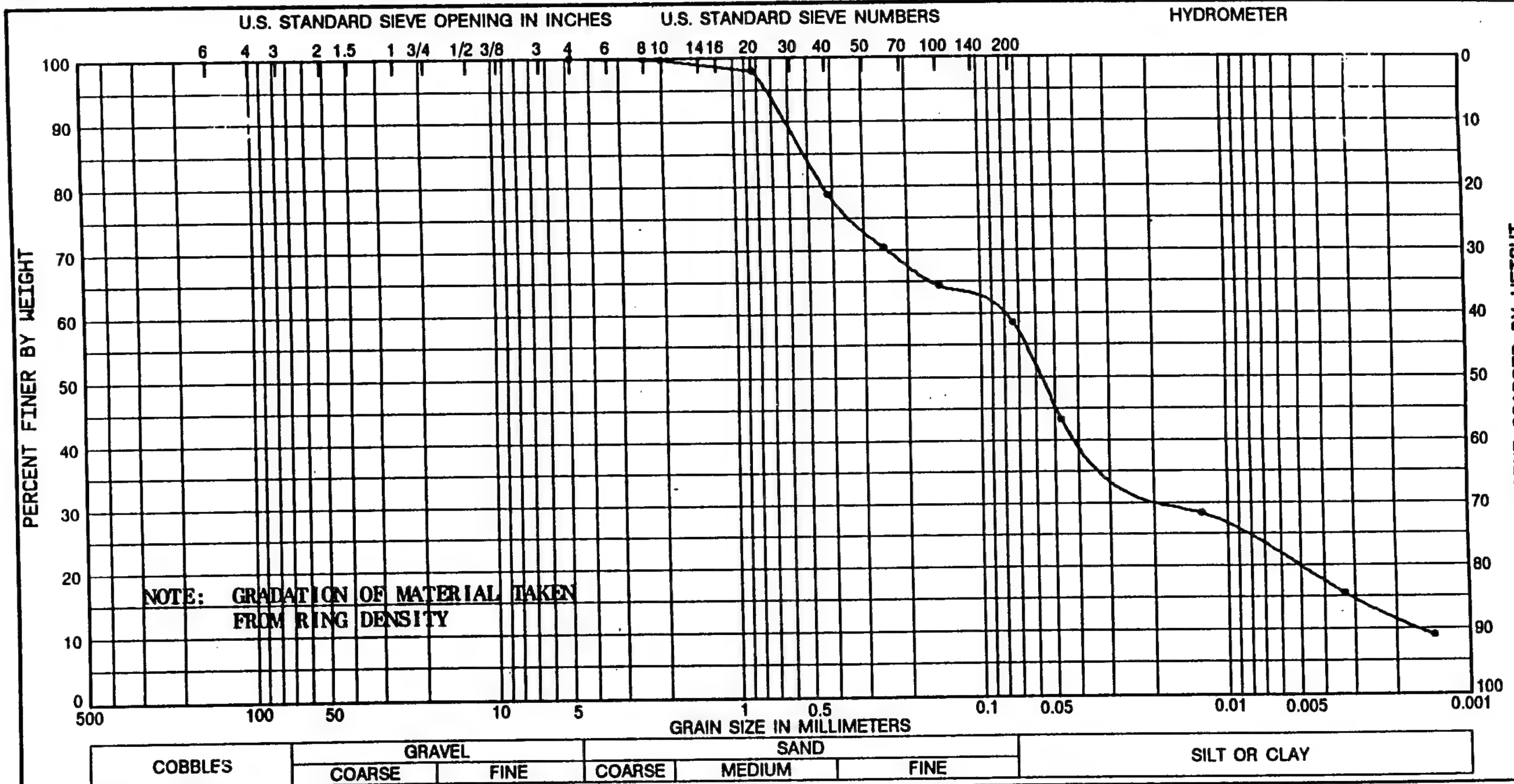
Boring No. NJV-124

Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-16.0 / -16.4'	(VISUAL) GRAY, SANDY LEAN CLAY (CL),	20.3			
		WITH A TRACE OF MICA.				
		SP. GRAVITY = 2.66				
		WET DENSITY = 121.1 PCF.				
		DRY DENSITY = 102.3 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/851D

Boring No. NJV-124

Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: VIBRACORE SEDIMENT SAMPLES	Boring No. NJV-125
Location: OFFSHORE OF NEW JERSEY	Lab No. 184/852
Boring Depth (ft): 18.00 — Elevation: ———	Work order: 7185
Datum/Notes: See grain size data on enclosed gradation curves.	Requisition: NAPEN-94-612

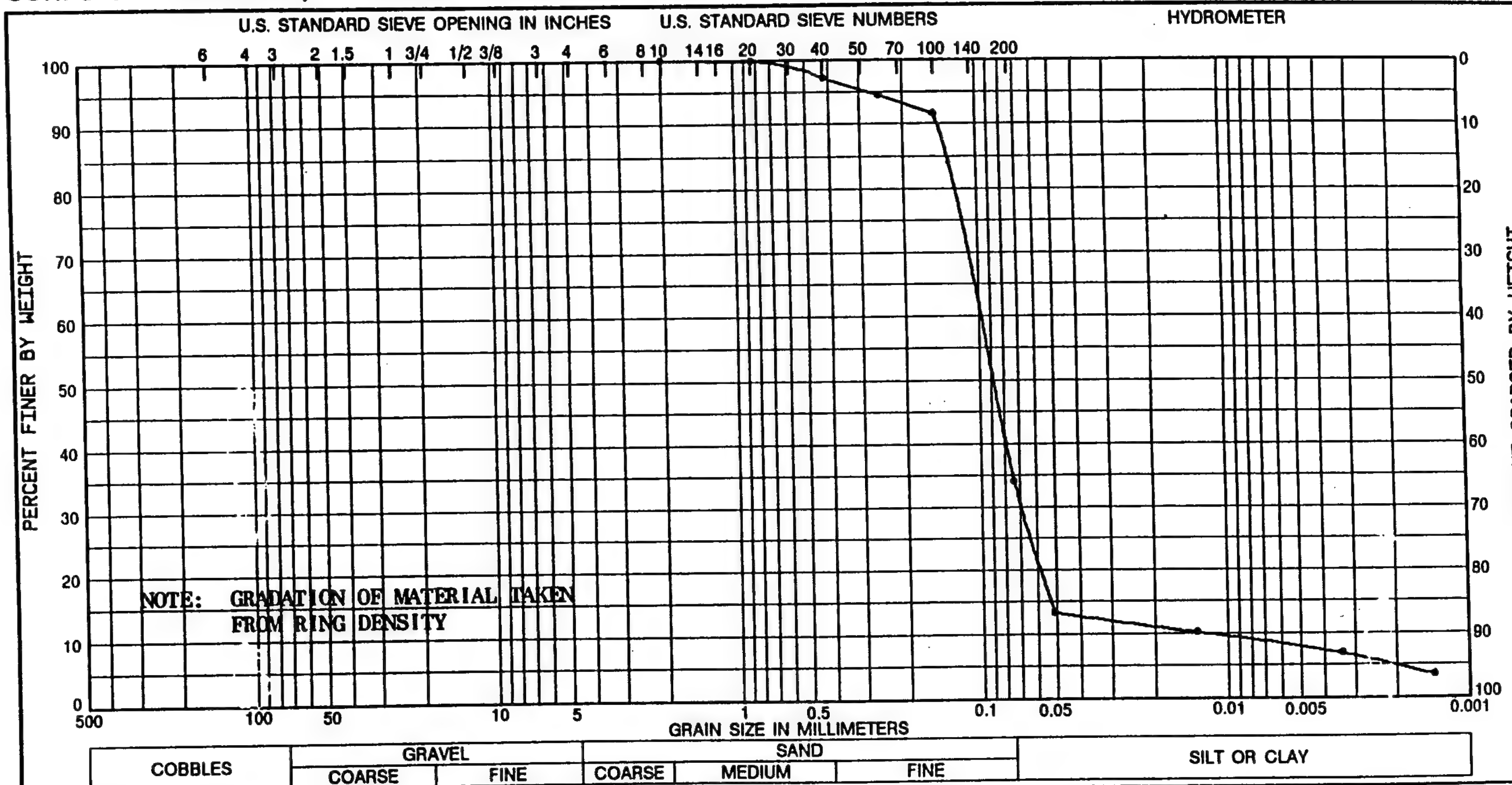
Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0–3		GRAY, SILTY SAND (SM), WITH A TRACE OF MICA.	A -1.5/-2.0' WET DEN. = 117.3, DRY DEN. = 92.6, M. C. = 26.7%
	3–5.4		GRAY, LAYERS AND POCKETS OF CLAYEY SAND (SC) AND POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZE SHELL FRAGMENTS.	MA -4.0/-4.3'
-5	5.4–9		GRAY, SANDY LEAN CLAY (CL), WITH A TRACE OF MICA.	B -5.3/-5.7' WET DEN. = 96.1, DRY DEN. = 66.5, M. C. = 44.5%
-10	9–14.5		GRAY, SANDY INORGANIC SILT LOW LL (ML), WITH A LITTLE ORGANIC MATTER.	C -11.1/-11.5' WET DEN. = 95.0, DRY DEN. = 59.0, M. C. = 61.0%
-15	14.5–18		TAN AND GRAY POORLY GRADED SAND (SP), WITH OCCASIONAL POCKETS OF ORGANIC MATTER.	D -15.6/-16.0' WET DEN. = 127.1, DRY DEN. = 109.9, M. C. = 15.7%
-20				

Date: 04/19/94

LABORATORY LOG AND SAMPLE DATUM

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



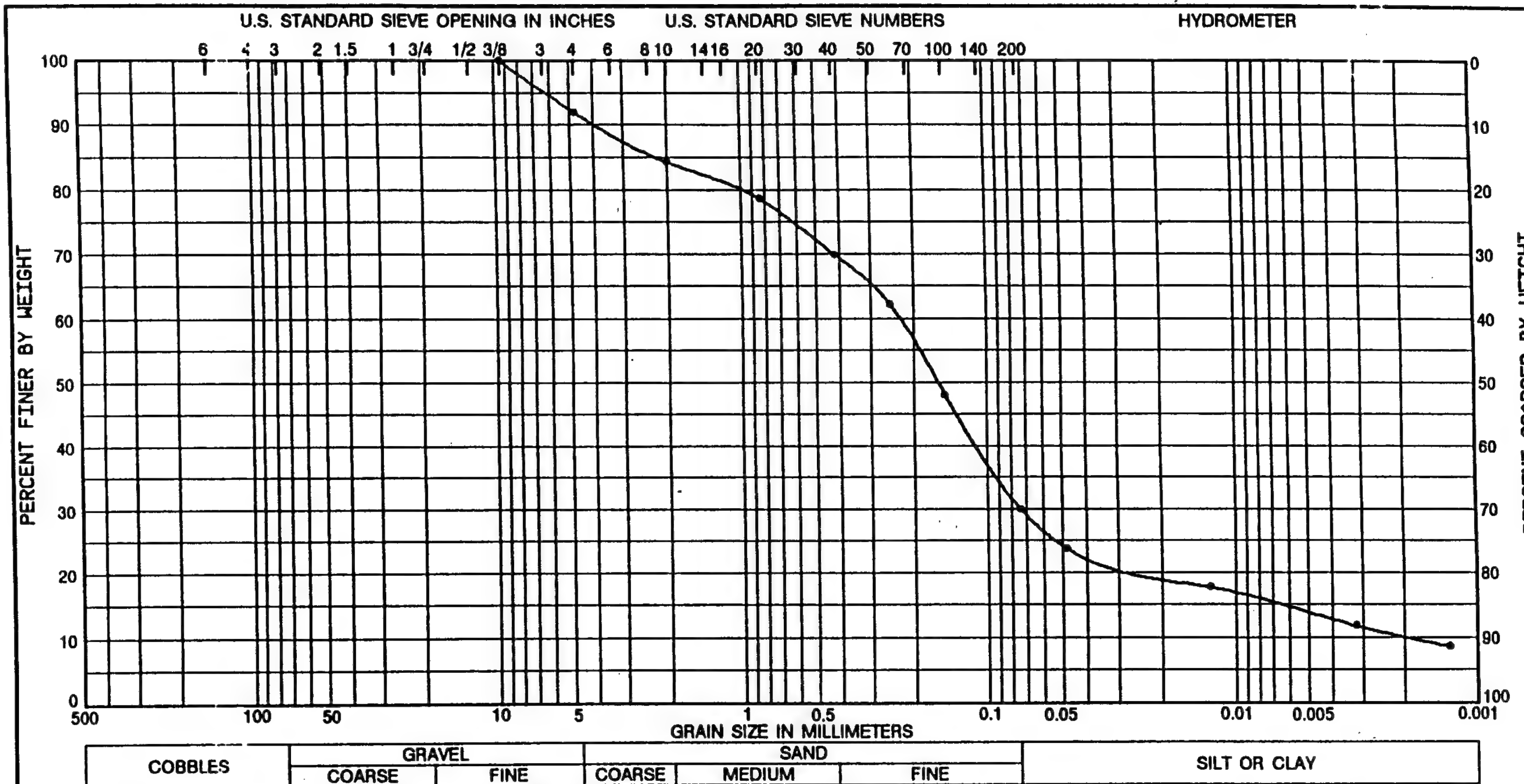
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-1.5 / -2.0'	(VISUAL) GRAY, SILTY SAND (SM), WITH	26.7			
		A TRACE OF MICA.				
		SP. GRAVITY = 2.71				
		WET DENSITY = 117.3 PCF.				
		DRY DENSITY = 92.6 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/852A
Boring No. NJV-125
Date 04/08/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



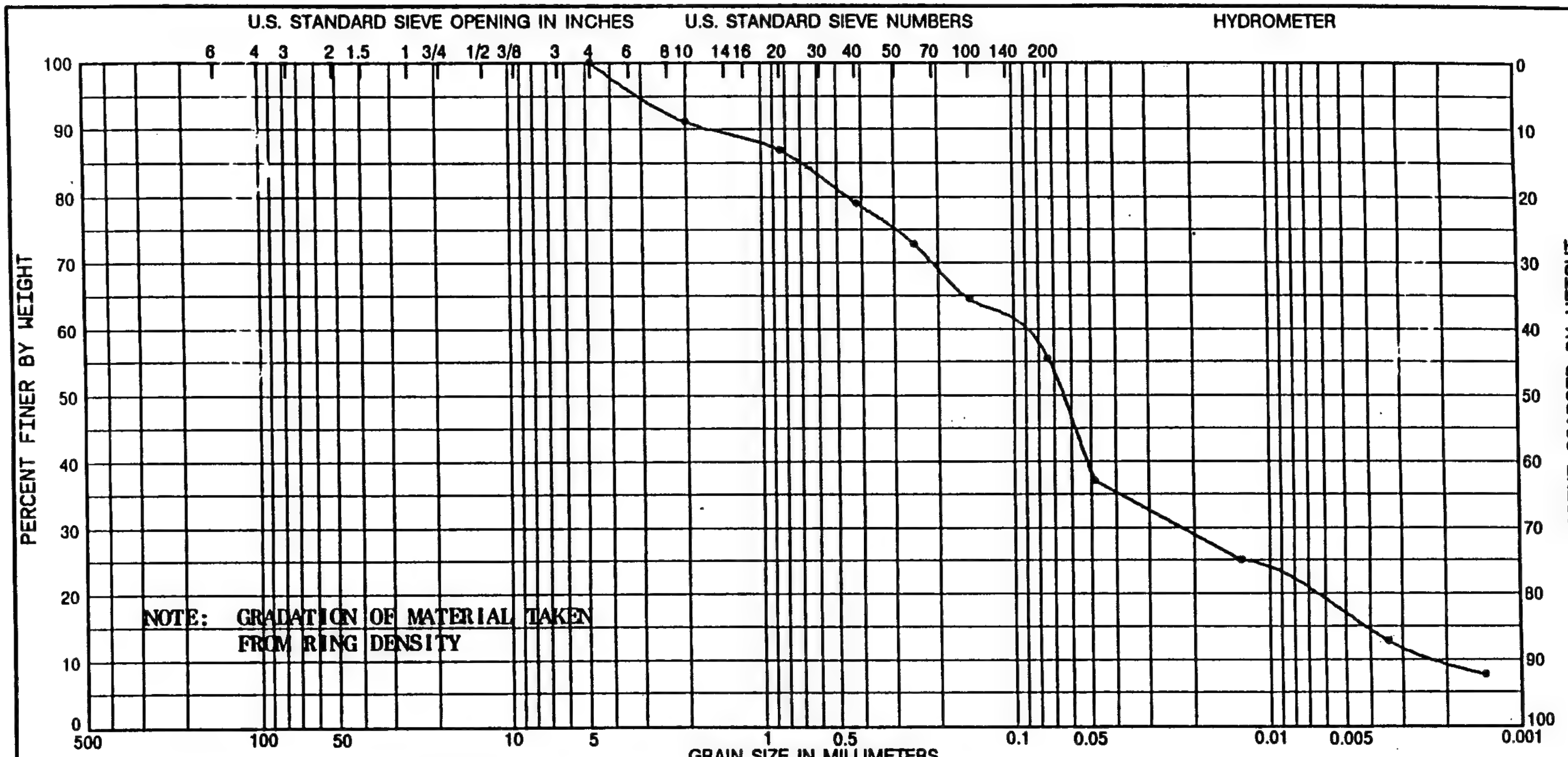
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 4.0' - 4.3'	(VISUAL) GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZE SHELL FRAGMENTS.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/852
Boring No. NJV-125
Date 04/15/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

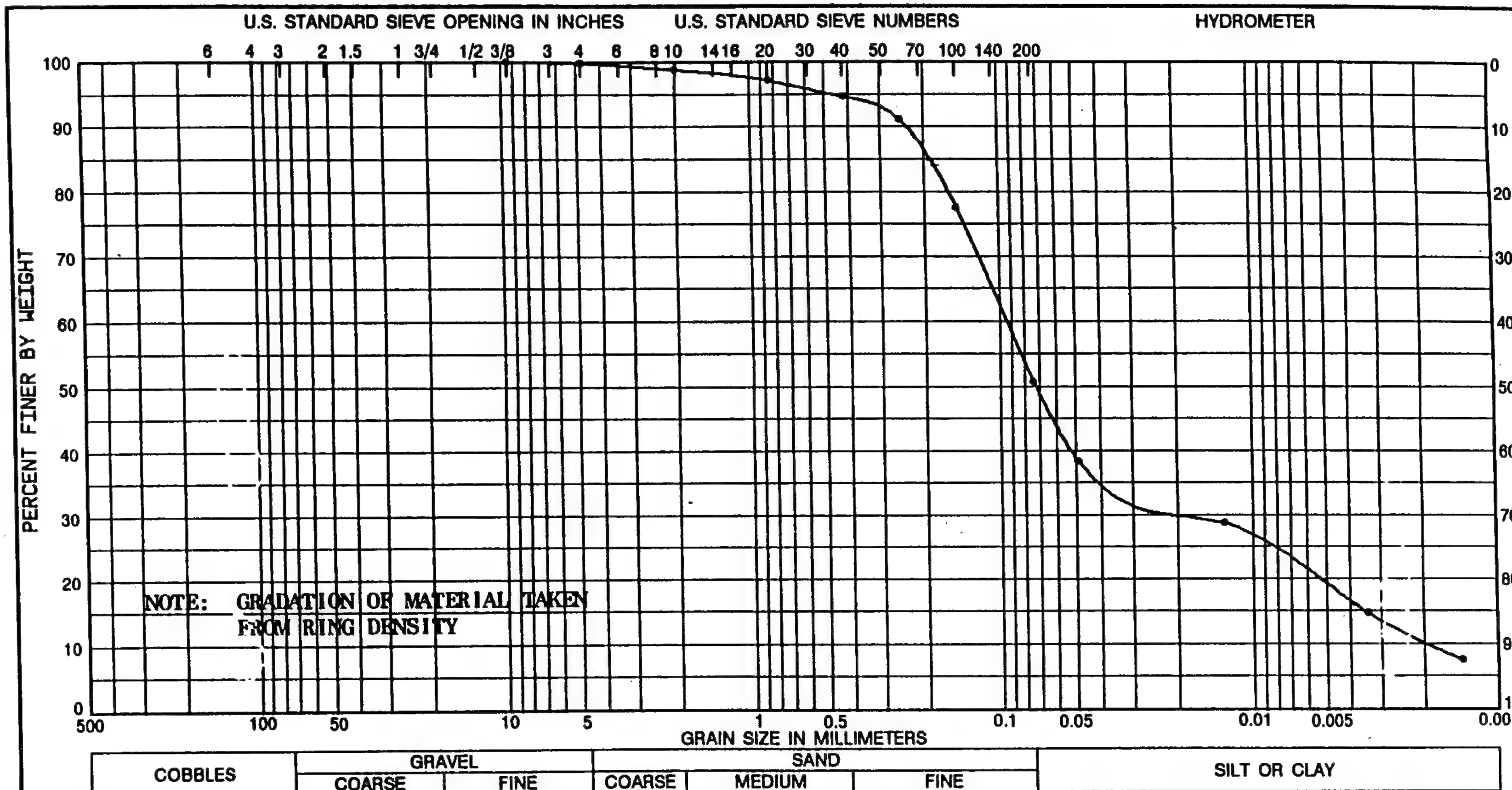
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-5.3 / -5.7'	(VISUAL) GRAY, SANDY LEAN CLAY (CL),	44.5			
		WITH A TRACE OF MICA.				
		SP. GRAVITY = 2.81				
		WET DENSITY = 98.1 PCF.				
		DRY DENSITY = 68.5.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/852B
Boring No. NJV-125
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



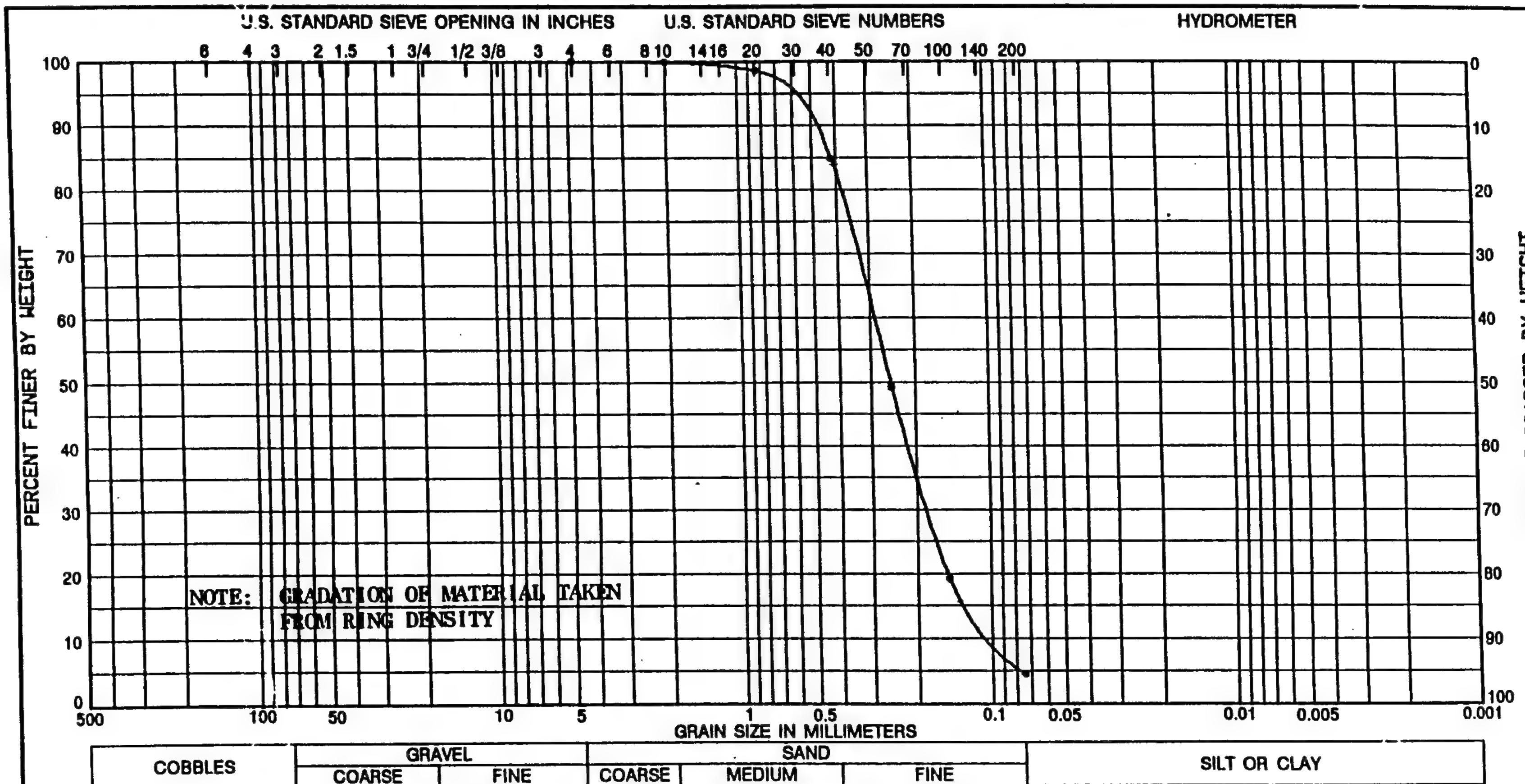
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-11.1 / -11.5'	(VISUAL) GRAY, SANDY INORGANIC SILT LOW	61.0			
		LL (ML), WITH A LITTLE ORGANICS.				
		SP. GRAVITY = 2.45				
		WET DENSITY = 95.0 PCF.				
		DRY DENSITY = 59.0 PCF.				

GRADATION CURVES

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/852C
Boring No. NJV-125
Date 04/08/94

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-15.6 / -16.0'	(VISUAL) TAN POORLY GRADED SAND	15.7			
		(SP), WITH A TRACE OF MICA.				
		SP. GRAVITY = 2.68				
		WET DENSITY = 127.1 PCF.				
		DRY DENSITY = 109.9 PCF.				

Project VIBRACORE SEDIMENT SAMPLES OFFSHORE OF NEW JERSEY
Lab No. 184/852D
Boring No. NJV-125
Date 04/08/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

Project: *VIBRACORE SEDIMENT SAMPLES*		Boring No. *NJV-126*
Location: *OFFSHORE OF NEW JERSEY*		Lab No. *184/853*
Boring Depth (ft): *18.00*	Elevation: ——	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*		Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0–1		TAN, SILTY SAND (SM).	
	1–3		GRAY, SILTY SAND (SM).	SA -1.8/-2.1'
	3–4.5		GRAY, FAT CLAY (CH), WITH A LITTLE SAND AND A TRACE OF MICA.	A -3.7/-4.1' WET DEN. = 104.1, DRY DEN. = 71.4, M. C. = 15.7%
-5	4.5–6.5		GRAY, LAYERS AND POCKETS OF FAT CLAY (CH) AND POORLY GRADED SILTY SAND (SP-SM).	MA -5.0/-5.4'
	6.5–8		GRAY, SILTY SAND (SM), WITH OCCASIONAL POCKETS OF PLASTIC FINES.	
	8–9.5		GRAY, POORLY GRADED SILTY SAND (SP-SM).	
-10	9.5–10.5		GRAY, SILTY SAND (SM), WITH PLASTIC FINES AND A TRACE OF SHELL FRAGMENTS.	B -9.5/-10.0' WET DEN. = 122.2, DRY DEN. = 100.3, M. C. = 21.8%
	10.5–11.5		GRAY, POORLY GRADED SAND (SP), WITH A TRACE OF SHELL FRAGMENTS.	SA -10.5/-10.8' MA -11.2/-11.5'
	11.5–12.5		GRAY, LAYERED LEAN CLAY (CL) AND POORLY GRADED SAND (SP).	C -12.0/-12.4' WET DEN. = 124.6, DRY DEN. = 104.1, M. C. = 19.7%
-15	12.5–18		GRAY AND TAN, POORLY GRADED SILTY SAND (SP-SM), WITH LAYERS AND POCKETS OF LEAN CLAY (CL).	D -15.4/-15.8' WET DEN. = 118.2, DRY DEN. ——, M. C. = ——.
-20				

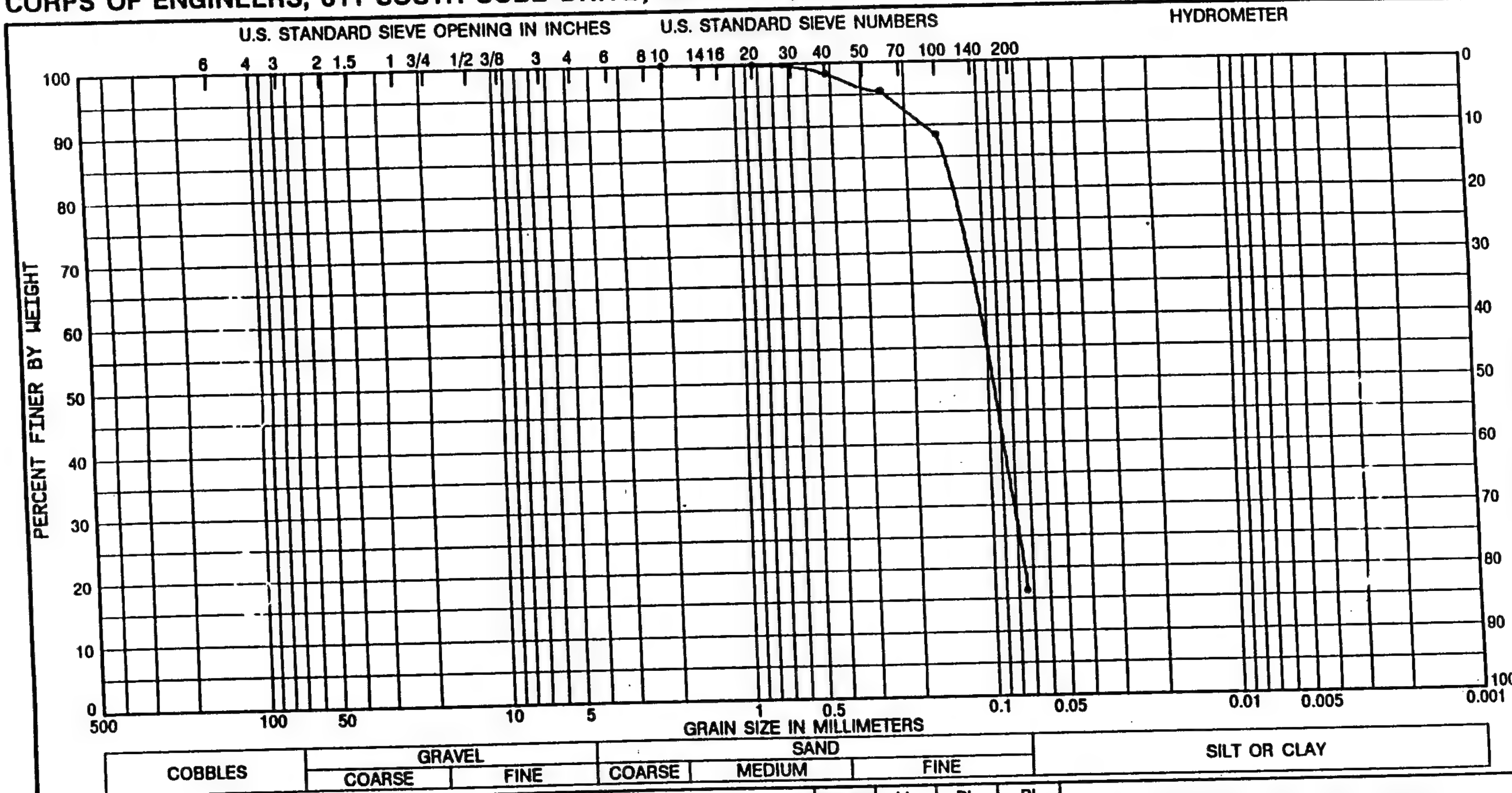
Date: *04/19/94*

LABORATORY LOG AND SAMPLE DATUM

Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



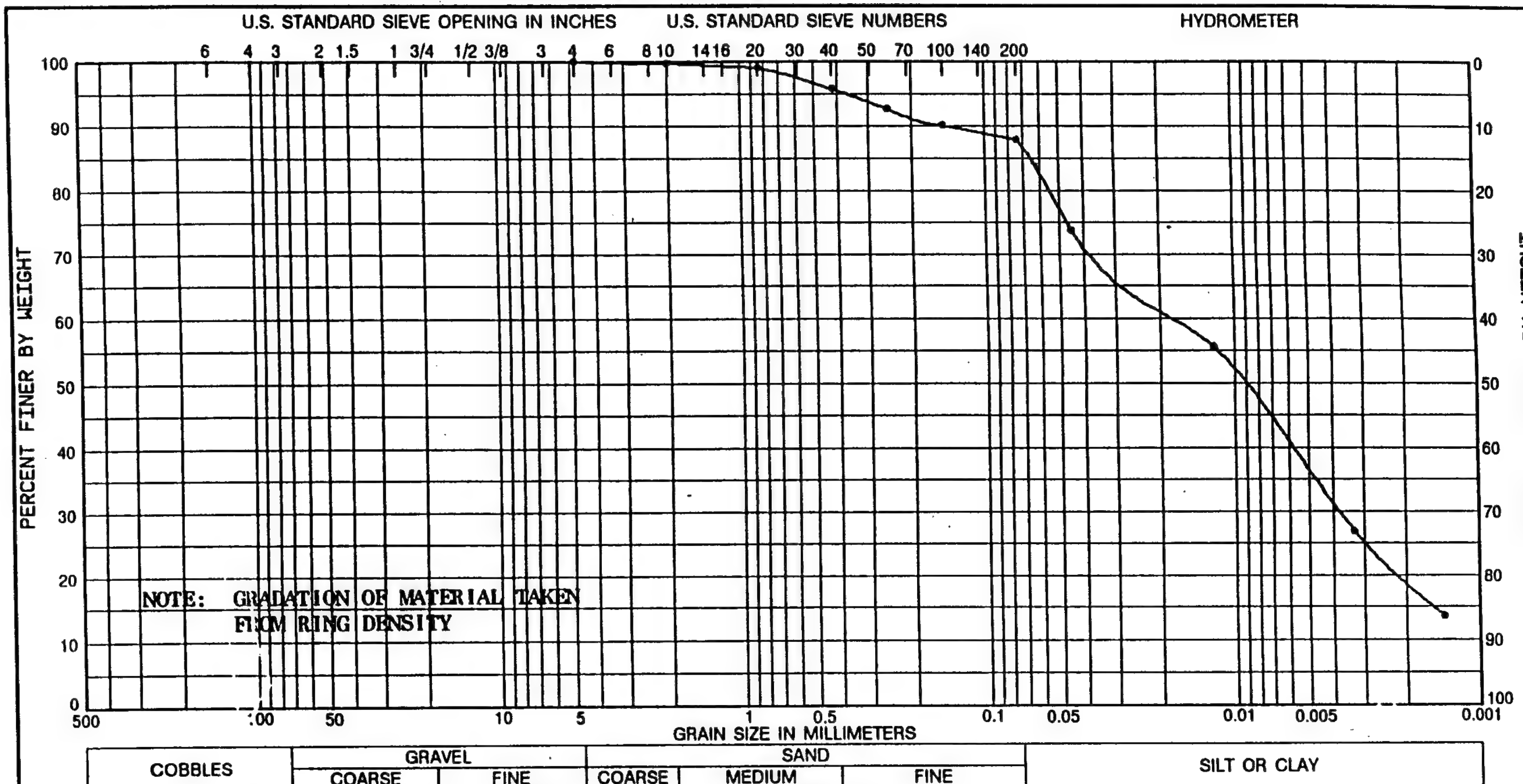
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	- 1.8 / - 2.1'	(VISUAL) GRAY, SILTY SAND (SM),				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/853
Boring No. NJV-126
Date 04/15/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



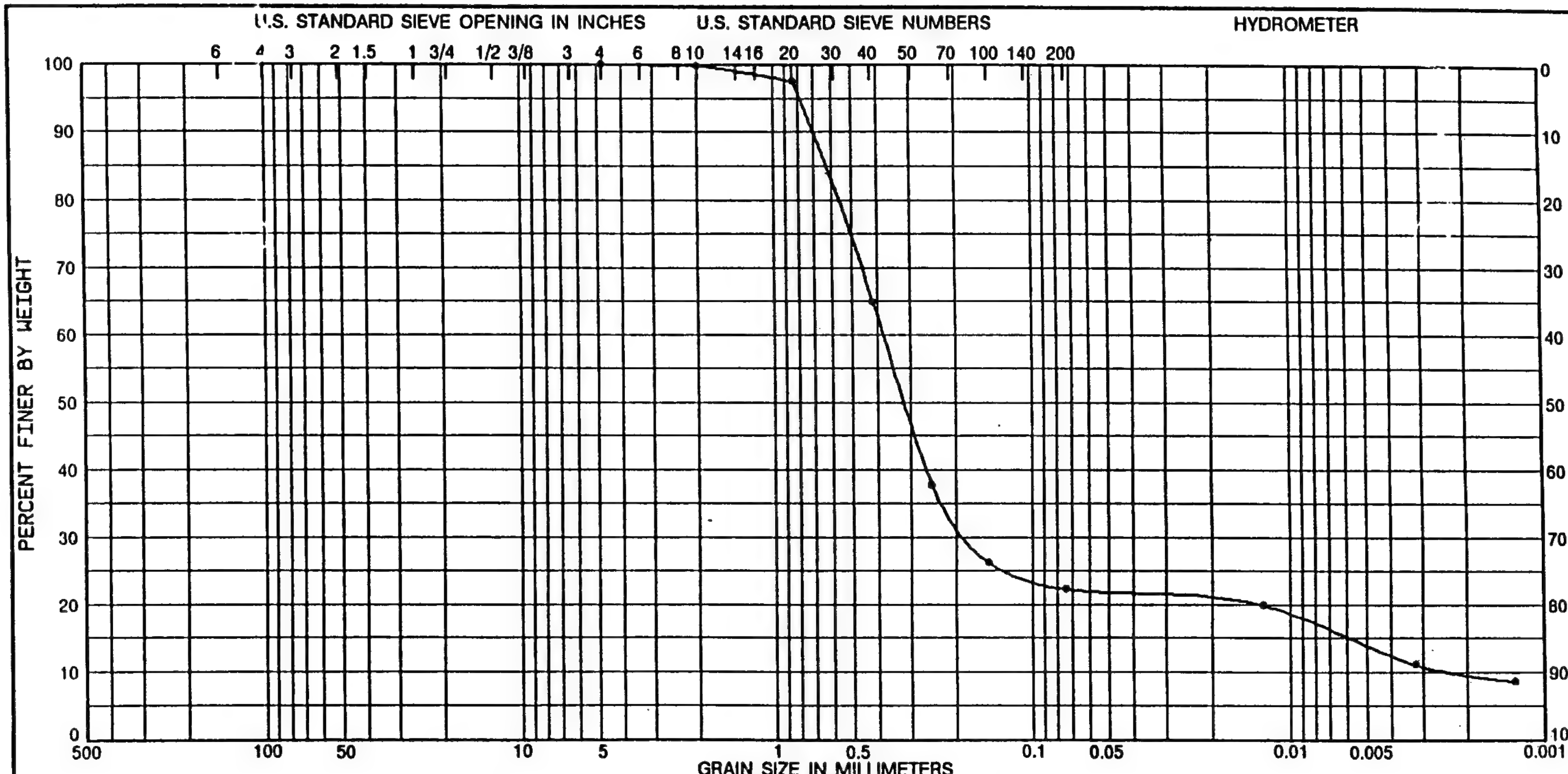
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-3.7 / -4.1'	(VISUAL) GRAY, FAT CLAY (CH), WITH A	45.7			
		LITTLE SAND SIZES AND A TRACE OF MICA.				
		SP. GRAVITY = 2.67				
		WET DENSITY = 104.1 PCF.				
		DRY DENSITY = 71.4 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/853A
Boring No. NJV-126
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 5.0 / - 5.4'	(VISUAL) GRAY, CLAYEY SAND (SC).				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/853

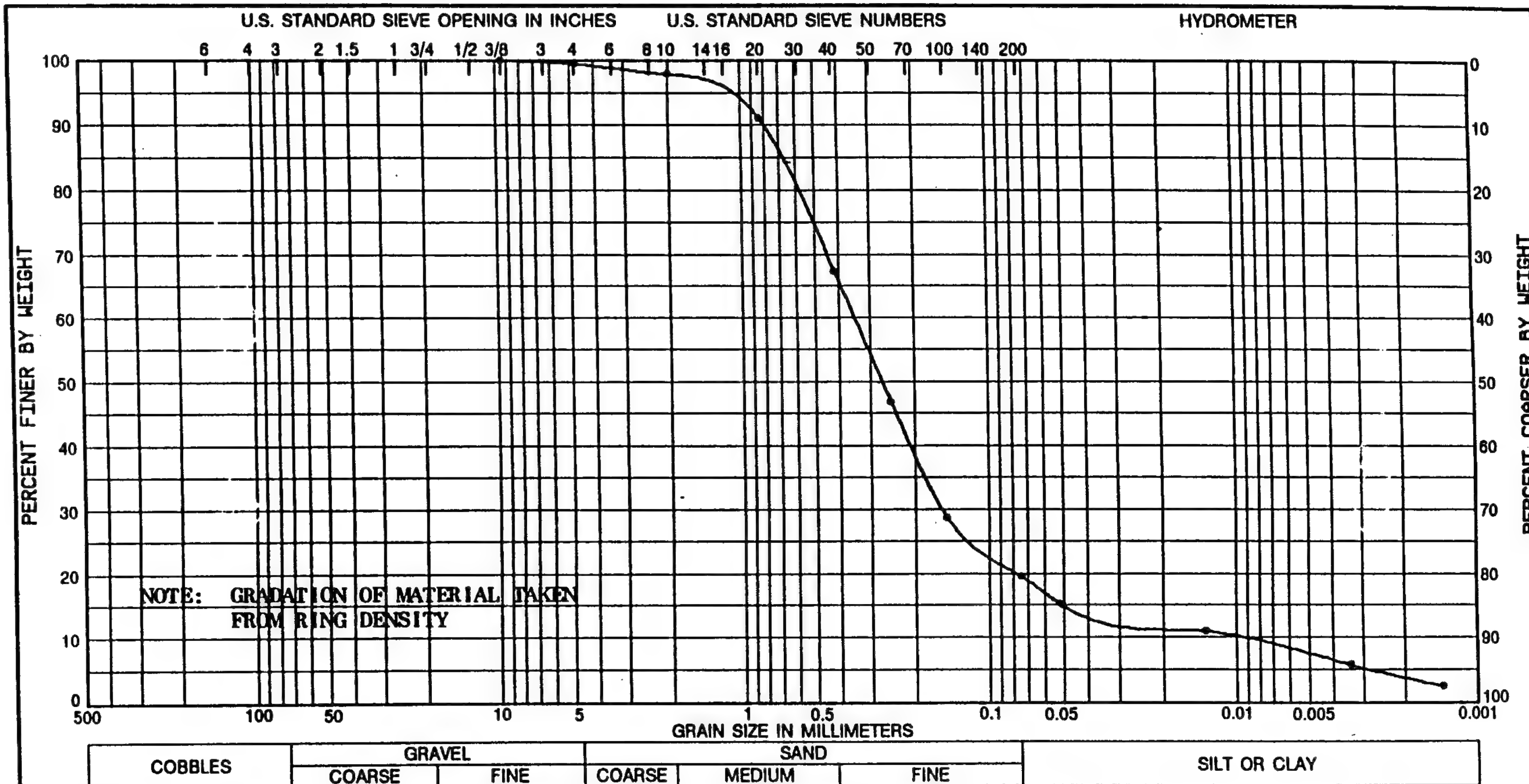
Boring No. NJV-126

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



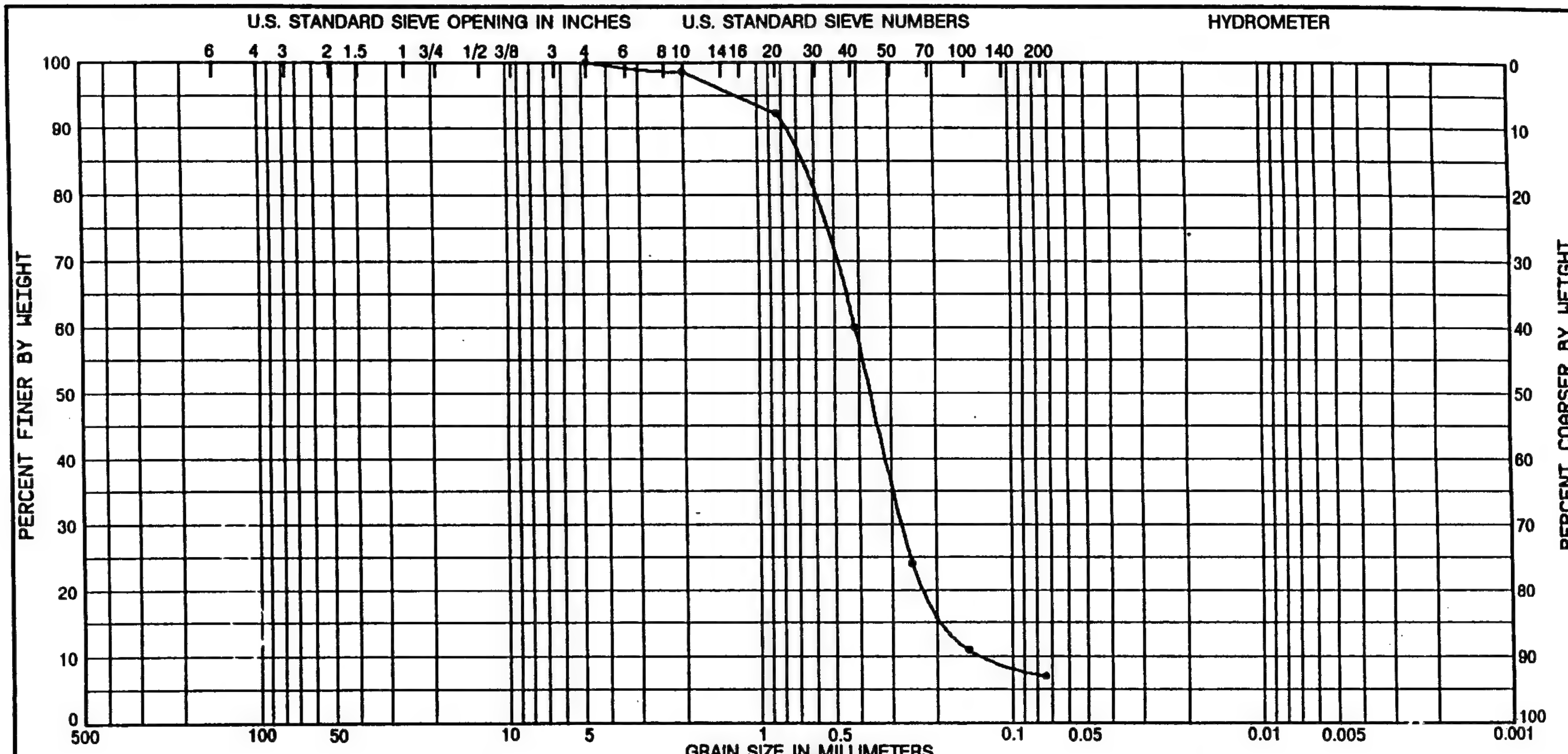
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-9.5 / -10.0'	(VISUAL) GRAY, SILTY SAND (SM), WITH	21.8			
		PLASTIC FINES AND A TRACE OF SHELL FRAG.				
		SP. GRAVITY = 2.66				
		WET DENSITY = 122.2 PCF.				
		DRY DENSITY = 100.3 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/853B
Boring No. NJV-126
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

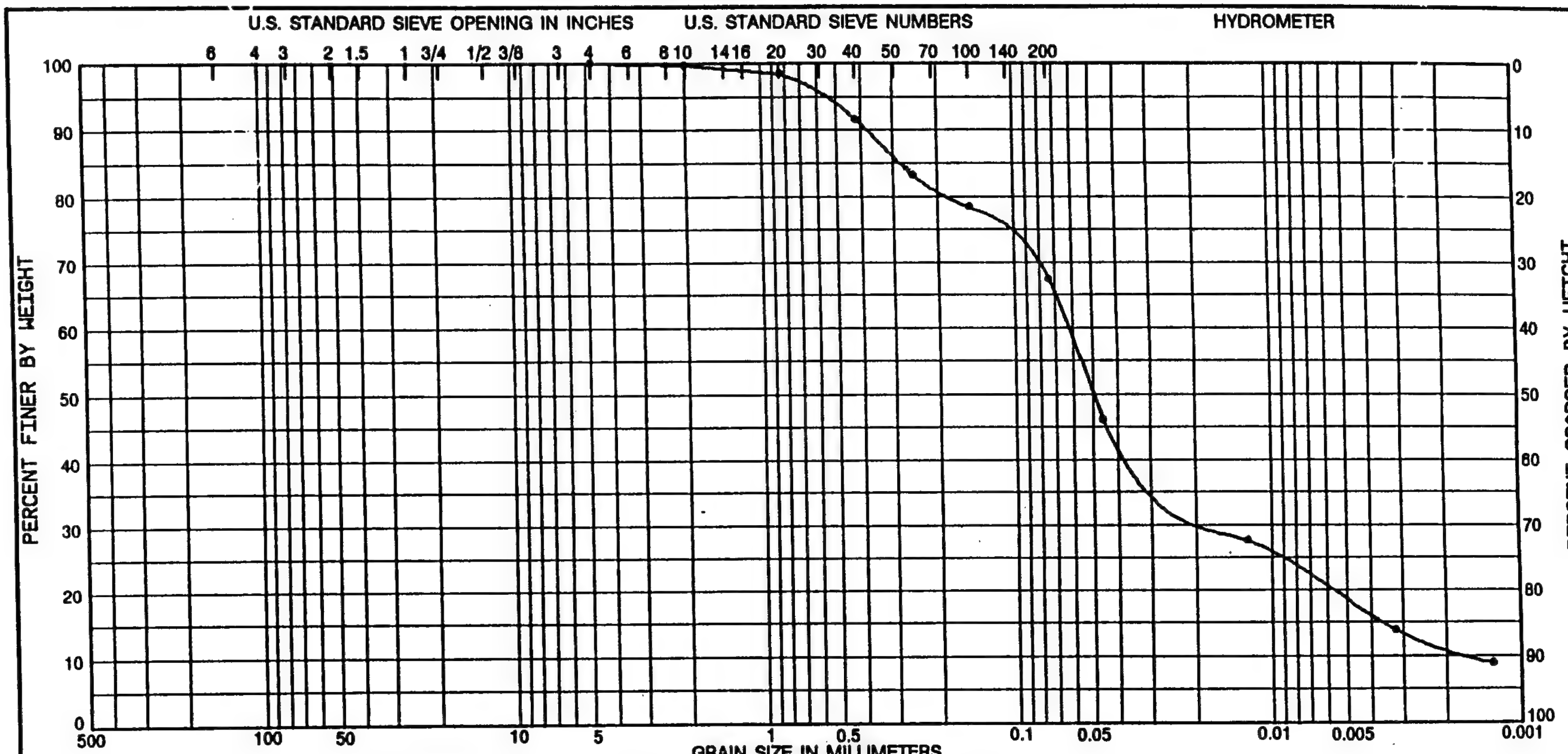
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	- 10.5 / -10.8'	(VISUAL) GRAY, POORLY GRADED SILTY SAND				
		(SP-SM), WITH A TRACE OF SHELL FRAGMENTS.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/853
Boring No. NJV-128
Date 04/15/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

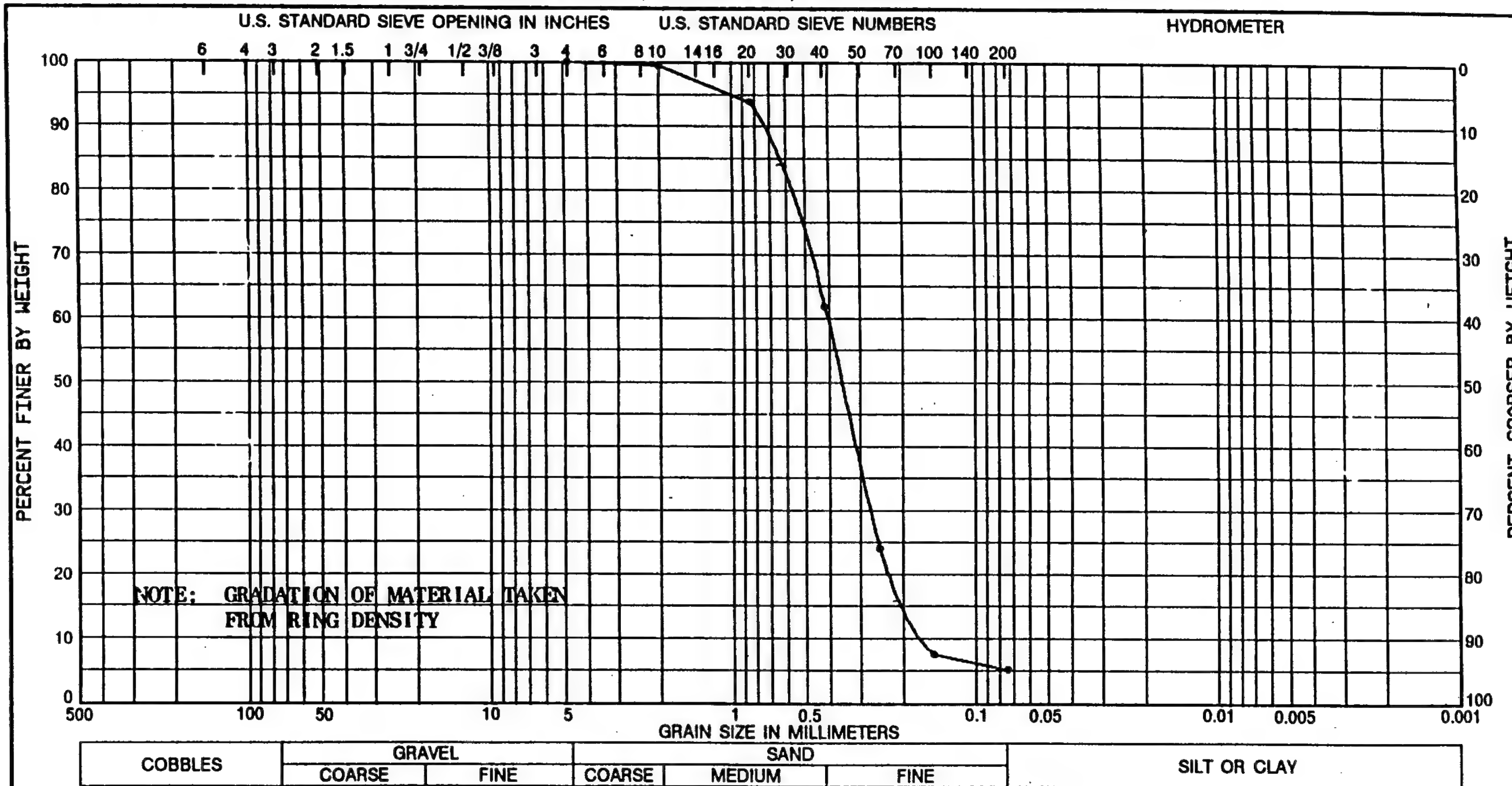
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	- 11.2 / -11.5'	(VISUAL) GRAY, LEAN CLAY (CL), WITH SOME SAND SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/853
Boring No. NJV-126
Date 04/15/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



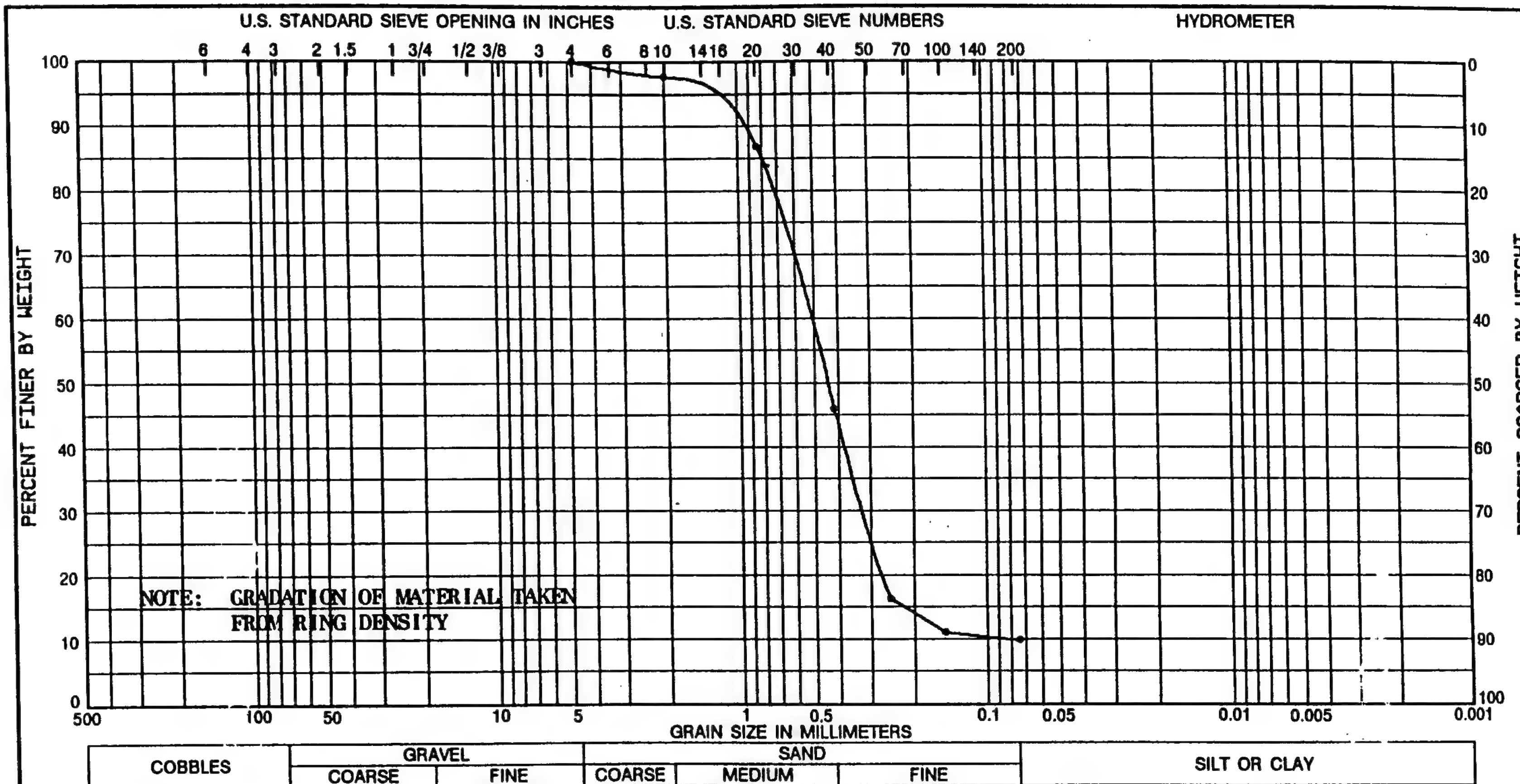
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-12.0 / -12.4'	(VISUAL) TAN, POORLY GRADED SILTY SAND	19.7			
		(SP-SM).				
		SP. GRAVITY = 2.67				
		WET DENSITY = 124.6.				
		DRY DENSITY = 104.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/853C
Boring No. NJV-128
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-16.4 / -16.8'	(VISUAL) LT. GRAY, POORLY GRADED SILTY				
		SAND (SP-SM).				
		SP. GRAVITY = 2.67				
		WET DENSITY = 118.2.				
		DRY DENSITY = ----				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/853D
Boring No. NJV-126
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

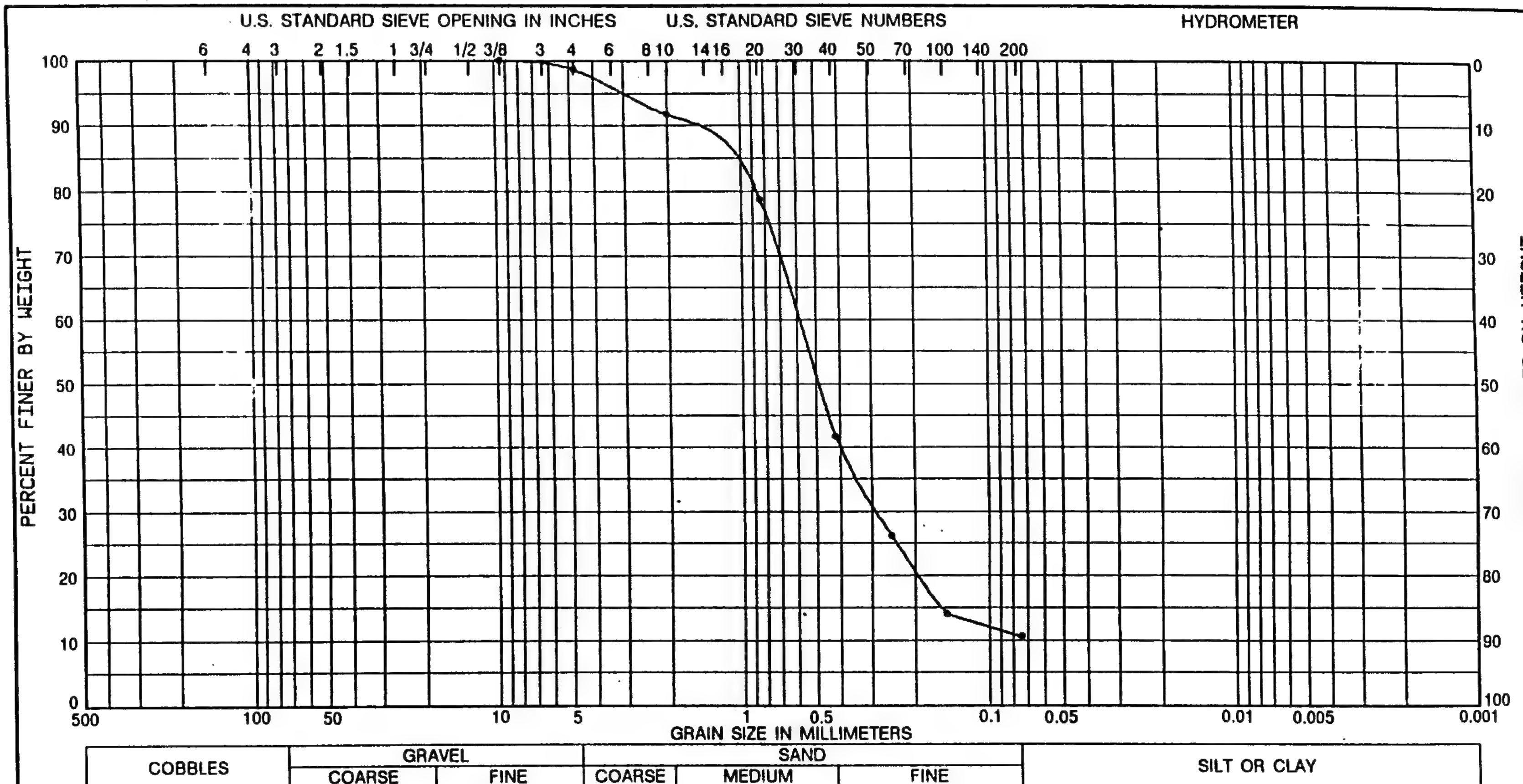
Project: *VIBRACORE SEDIMENT SAMPLES*	Boring No. *NJV-127*
Location: *OFFSHORE OF NEW JERSEY*	Lab No. *184/854*
Boring Depth (ft): *17.50* Elevation: ——	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*	Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0–1		GRAY AND TAN POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.	SA -0.4/-0.7
	1–5		GRAY, FAT CLAY (CH), WITH A LITTLE SAND SIZES AND A TRACE OF MICA.	B -1.7/-2.1 WET DEN. = 115.1, DRY DEN. = 85.3, M. C. = 34.9%
-5	5–6.5		GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES.	MA -5.6/-5.9
	6.5–9		GRAY, POORLY GRADED SILTY SAND (SP-SM).	B -7.0/-7.4 WET DEN. = 133.8, DRY DEN. = 113.7, M. C. = 17.7%
-10	9–11.7		TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES WITH A LAYER OF GRAY, FAT CLAY (CH) AT -10.0/-10.1'.	C -11.3/-11.7 WET DEN. = 137.1, DRY DEN. = 123.2, M. C. = 11.3%
	11.7–12.8		TAN, POORLY GRADED SAND (SP), SITH SOME GRAVEL SIZES.	SA -11.9/-12.3
-15	12.8–17.5		TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES.	D -13.0/-13.4 WET DEN. = 118.6, DRY DEN. = 105.1, M. C. = 12.8% SA -16.4/-17.1

Date: *04/18/94* LABORATORY LOG AND SAMPLE DATUM Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



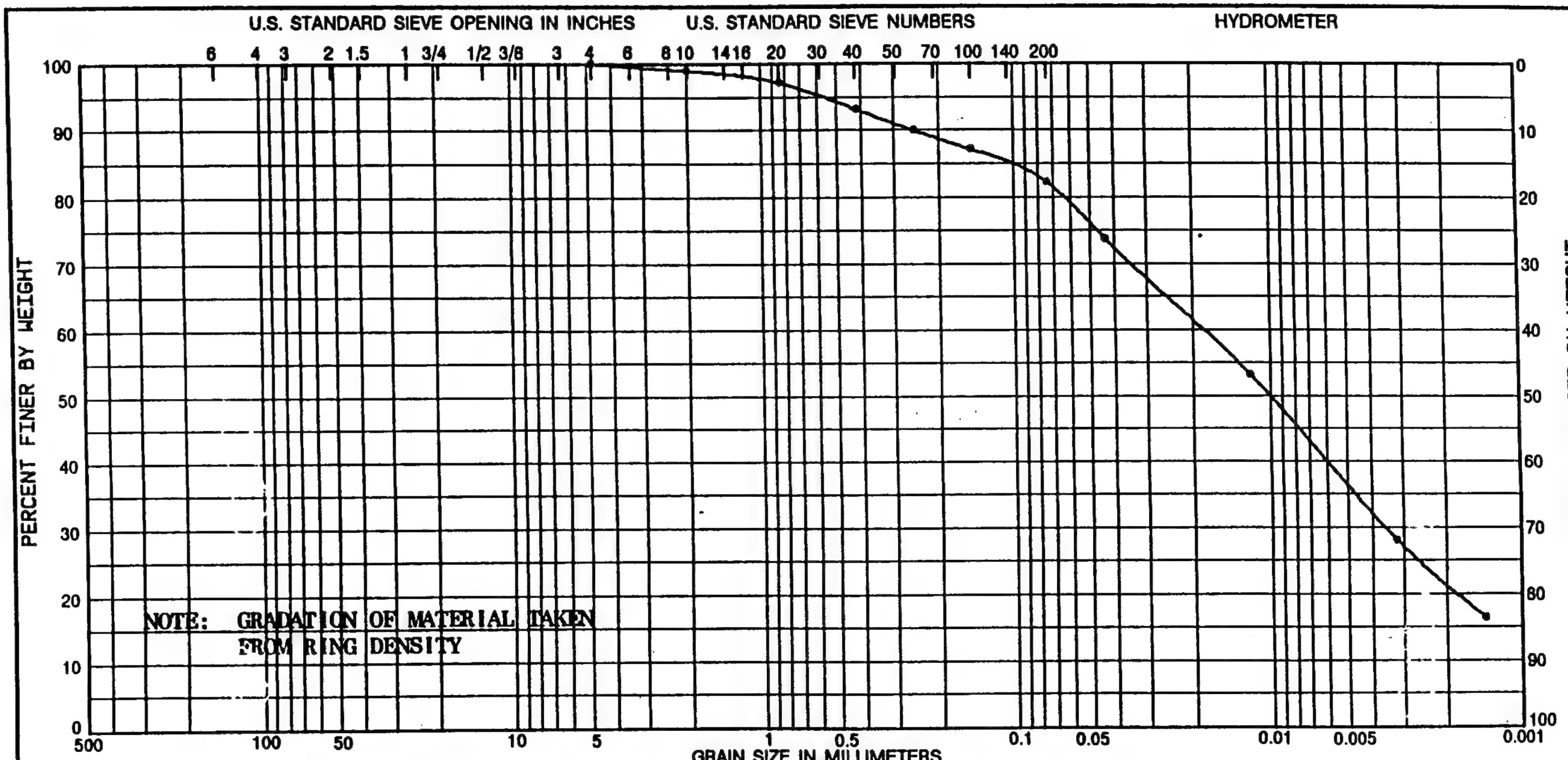
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	- 0.4 / - 0.7'	(VISUAL) GRAY, POORLY GRADED SILTY SAND				
		(SP-SM), WITH A TRACE OF GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/854
Boring No. NJV-127
Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

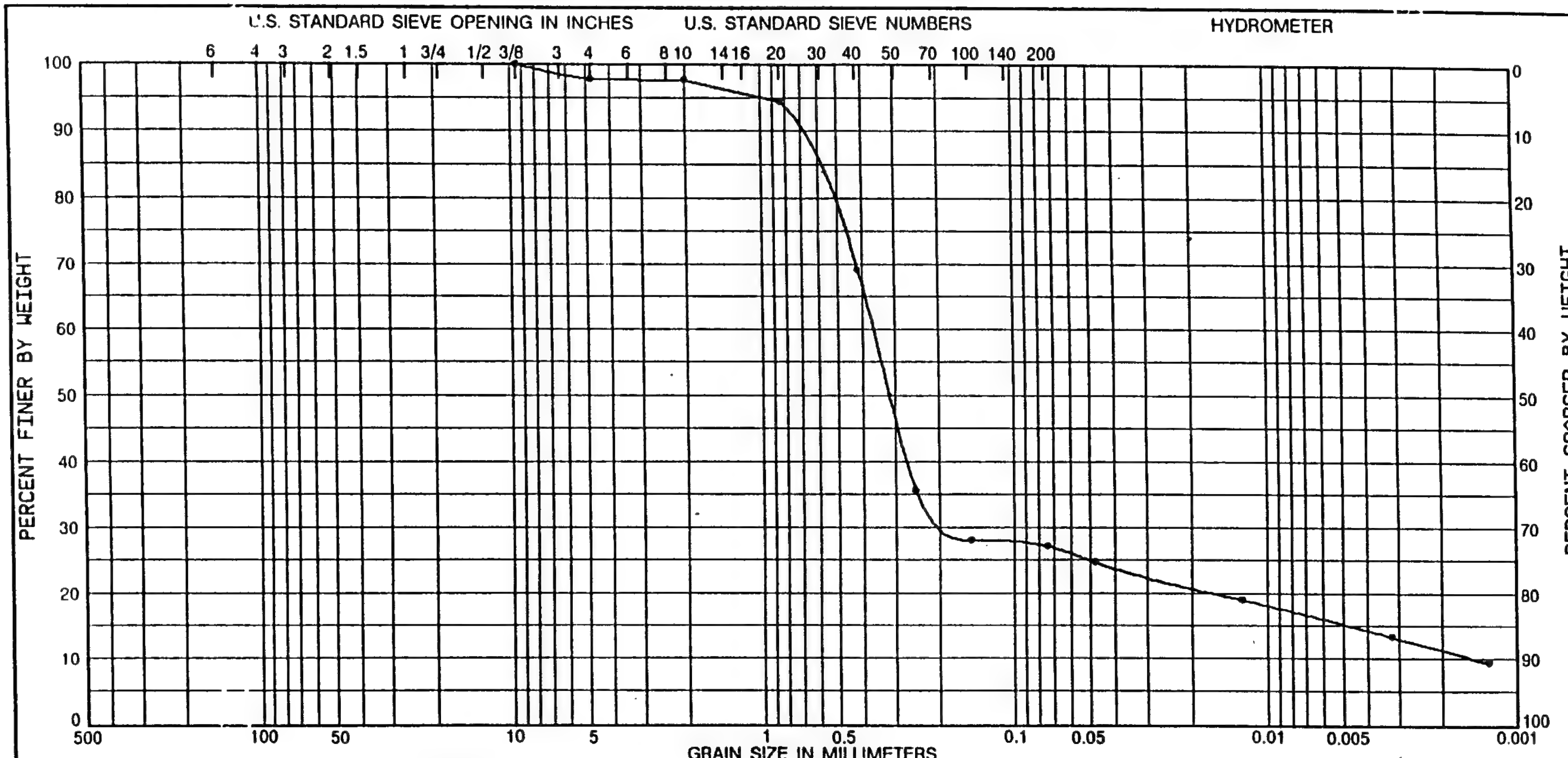
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-1.7 / -2.1'	(VISUAL) DK. GRAY, FAT CLAY (CH), WITH	34.9			
		A LITTLE SAND AND A TRACE OF MICA.				
		SP. GRAVITY = 2.74				
		WET DENSITY = 115.1 PCF.				
		DRY DENSITY = 85.3 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/854A
Boring No. NJV-127
Date 04/08/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 5.6 / - 5.9'	(VISUAL) GRAY, CLAYEY SAND (SC), WITH A TRACE OF GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES OFFSHORE OF NEW JERSEY

Lab No. 184/854

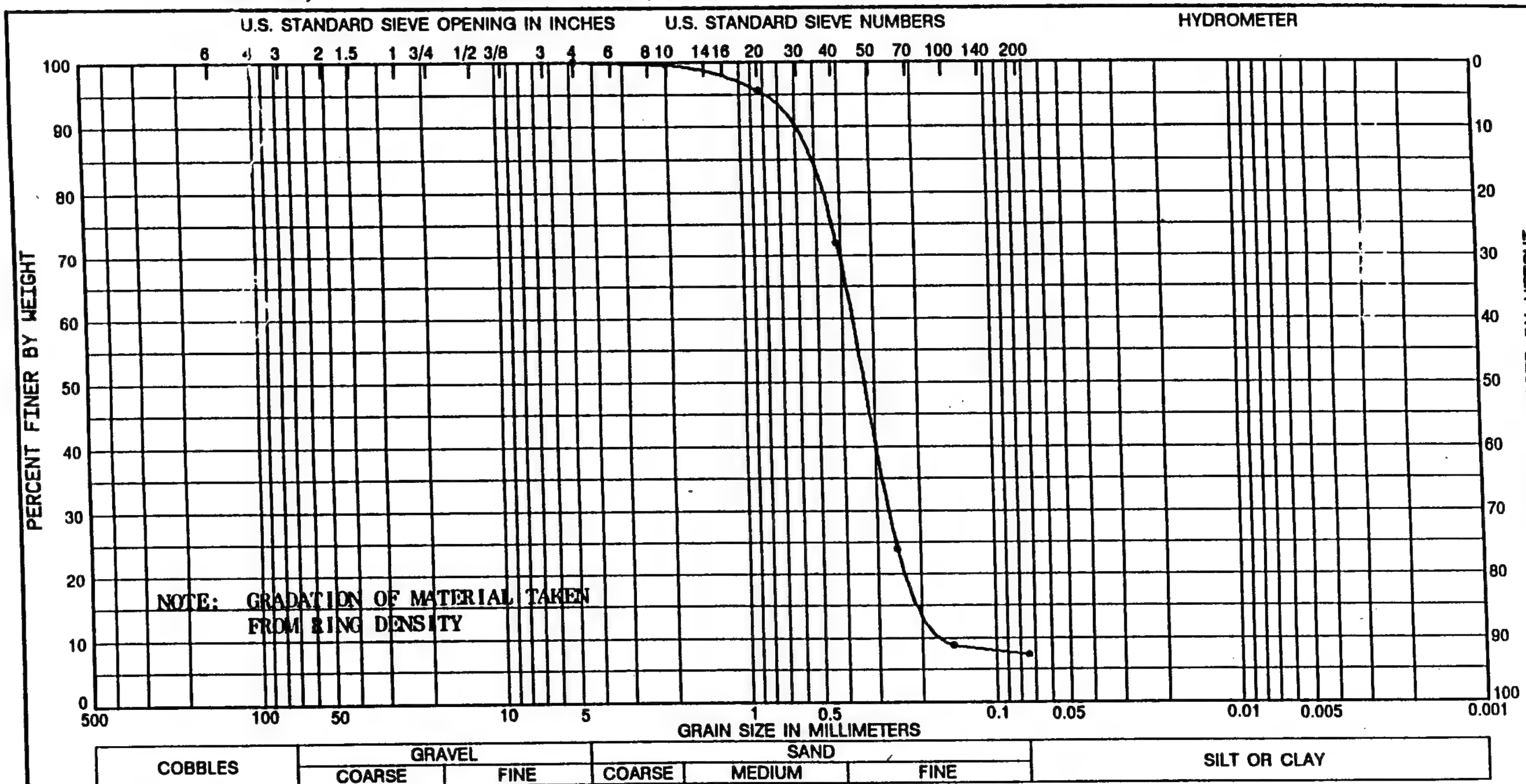
Boring No. NJV-127

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



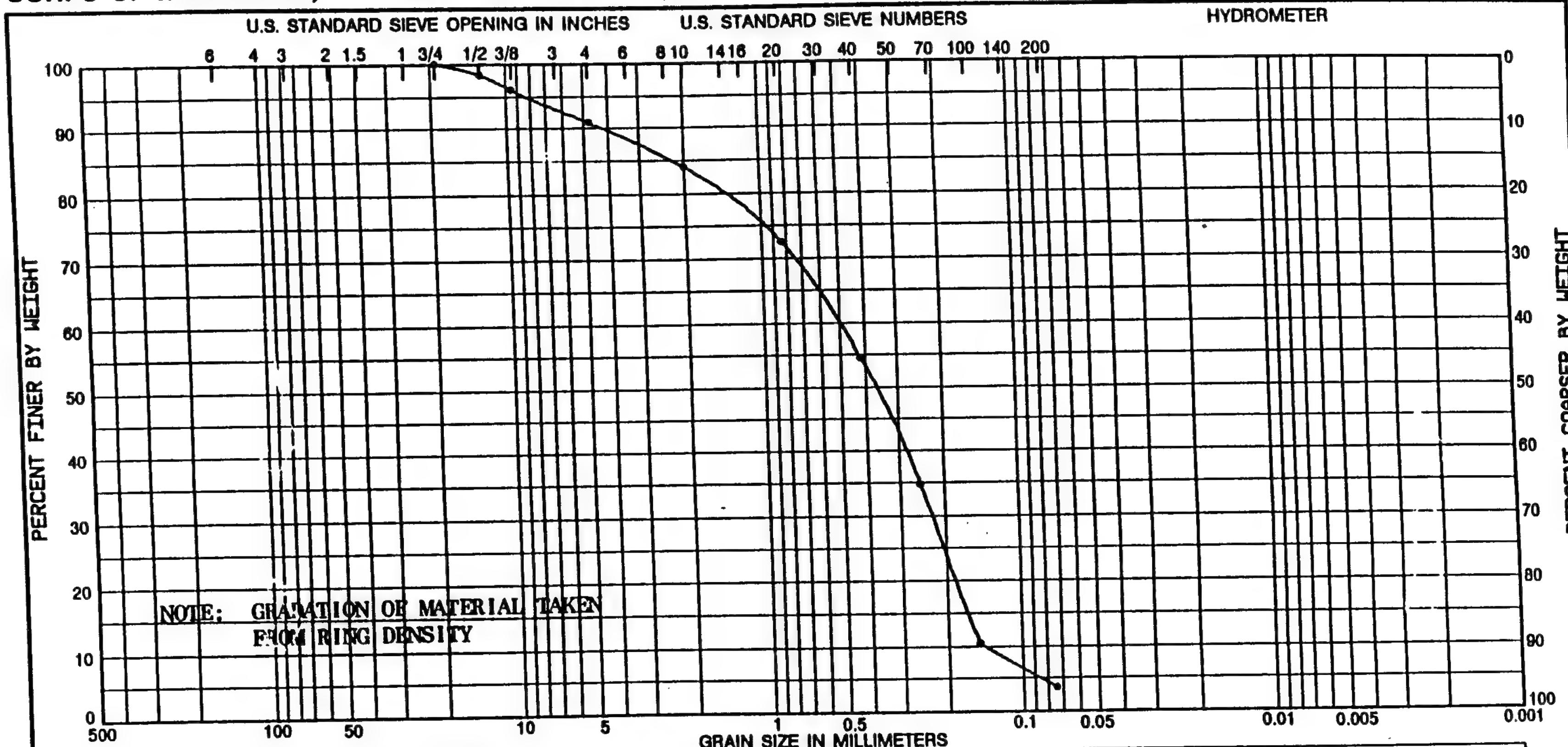
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-7.0 / -7.4'	(VISUAL) GRAY, POORLY GRADED SILTY SAND	17.7			
		(SP-SM).				
		SP. GRAVITY = 2.72				
		WET DENSITY = 133.8 PCF.				
		DRY DENSITY = 113.7 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/854B
Boring No. NJV-127
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

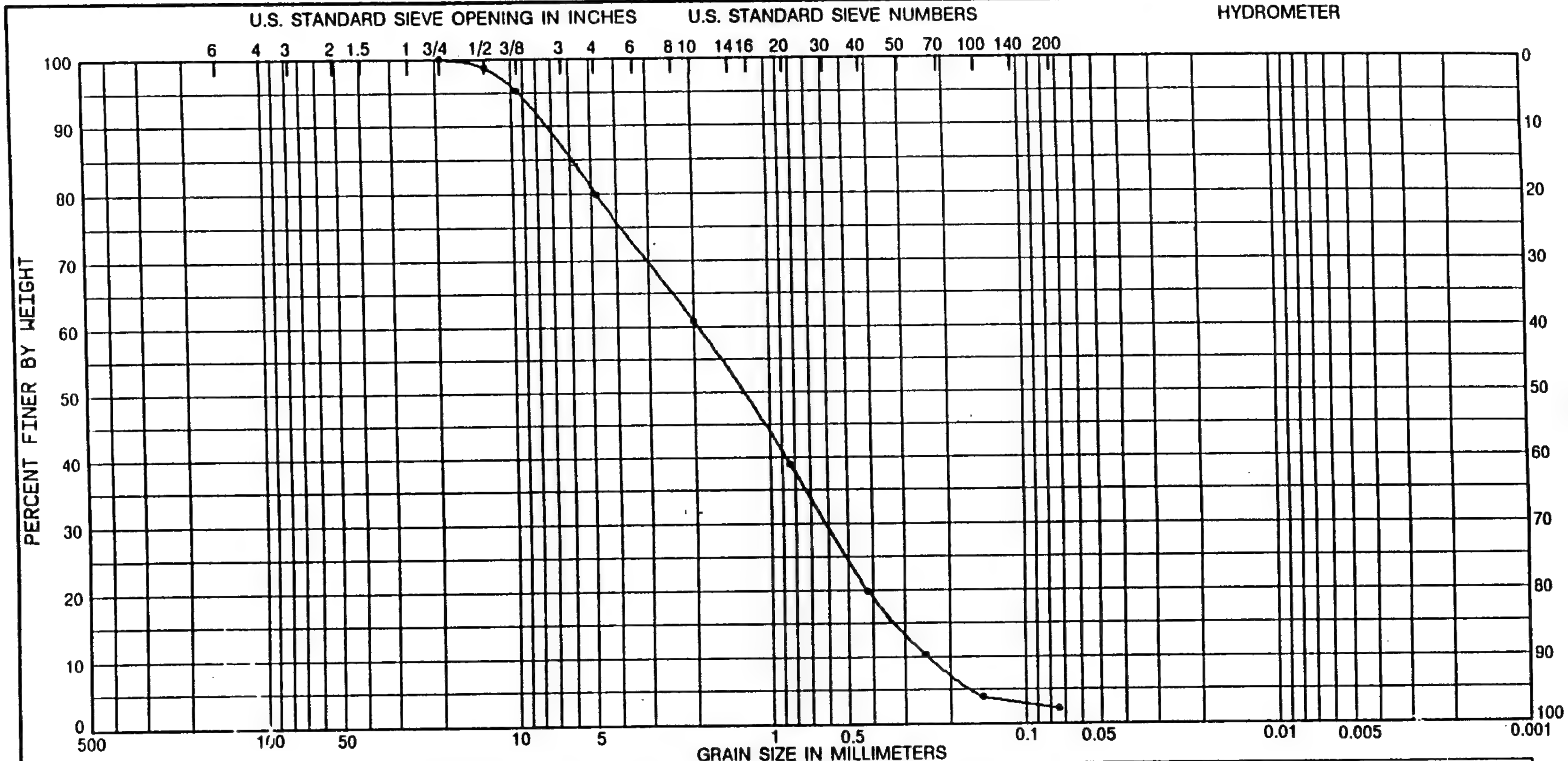
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-11.3 / -11.7'	(VISUAL) TAN POORLY GRADED SAND	11.3			
		(SP), WITH A TRACE OF GRAVEL SIZES.				
		SP. GRAVITY = 2.68				
		WET DENSITY = 137.1 PCF.				
		DRY DENSITY = 123.2 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/854C
Boring No. NJV-127
Date 04/08/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	- 11.9 / -12.3'	(VISUAL) TAN POORLY GRADED SAND (SP), WITH SOME GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES OFFSHORE OF NEW JERSEY

Lab No. 184/854

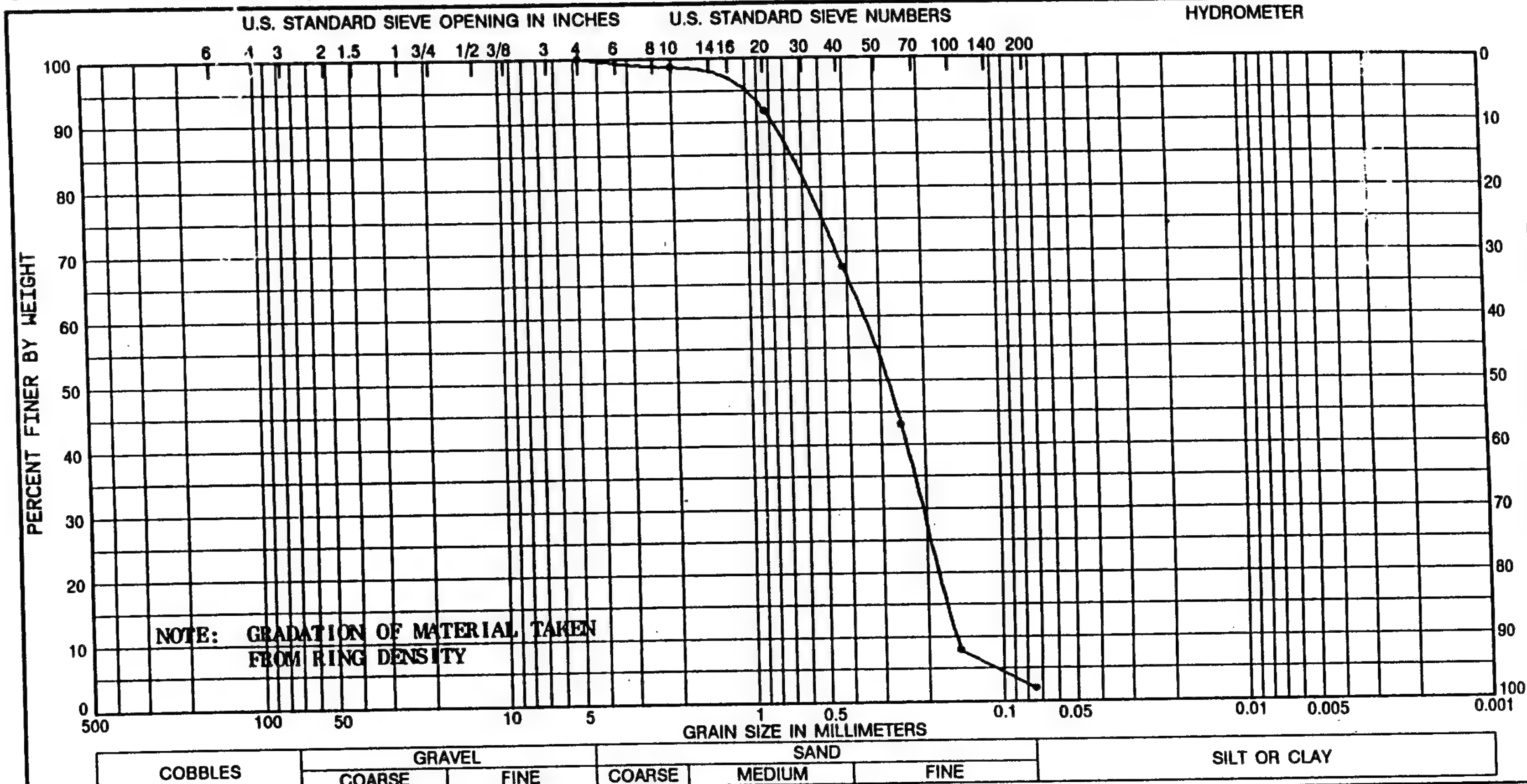
Boring No. NJV-127

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



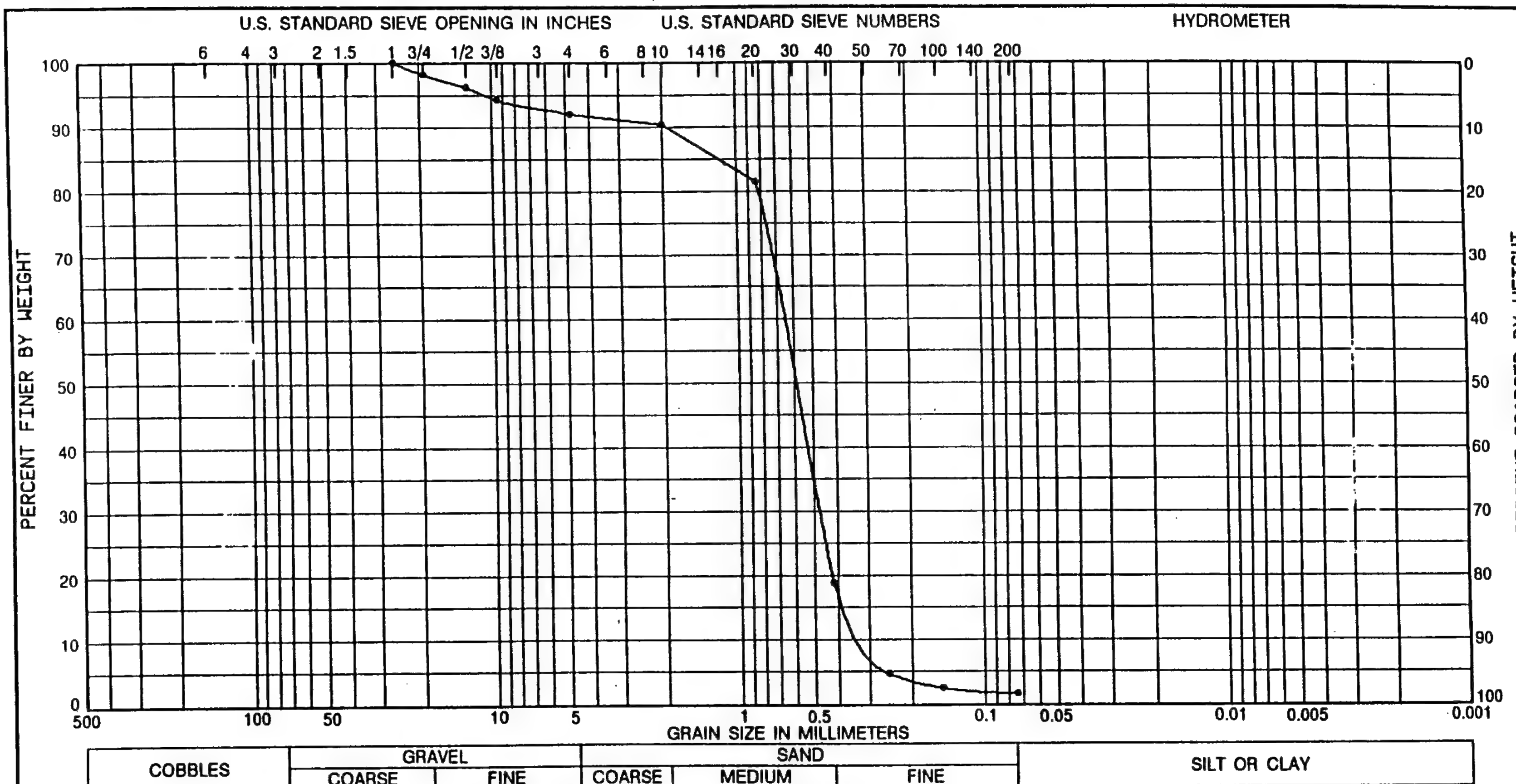
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-13.0 / -13.4'	(VISUAL) TAN POORLY GRADED SAND (SP).	12.8			
		SP. GRAVITY = 2.67				
		WET DENSITY = 118.6 PCF.				
		DRY DENSITY = 105.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/854D
Boring No. NJV-127
Date 04/06/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	- 16.4 / -17.1'	(VISUAL) TAN, POORLY GRADED SILTY SAND (SP), WITH A TRACE OF GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/854

Boring No. NJV-127

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

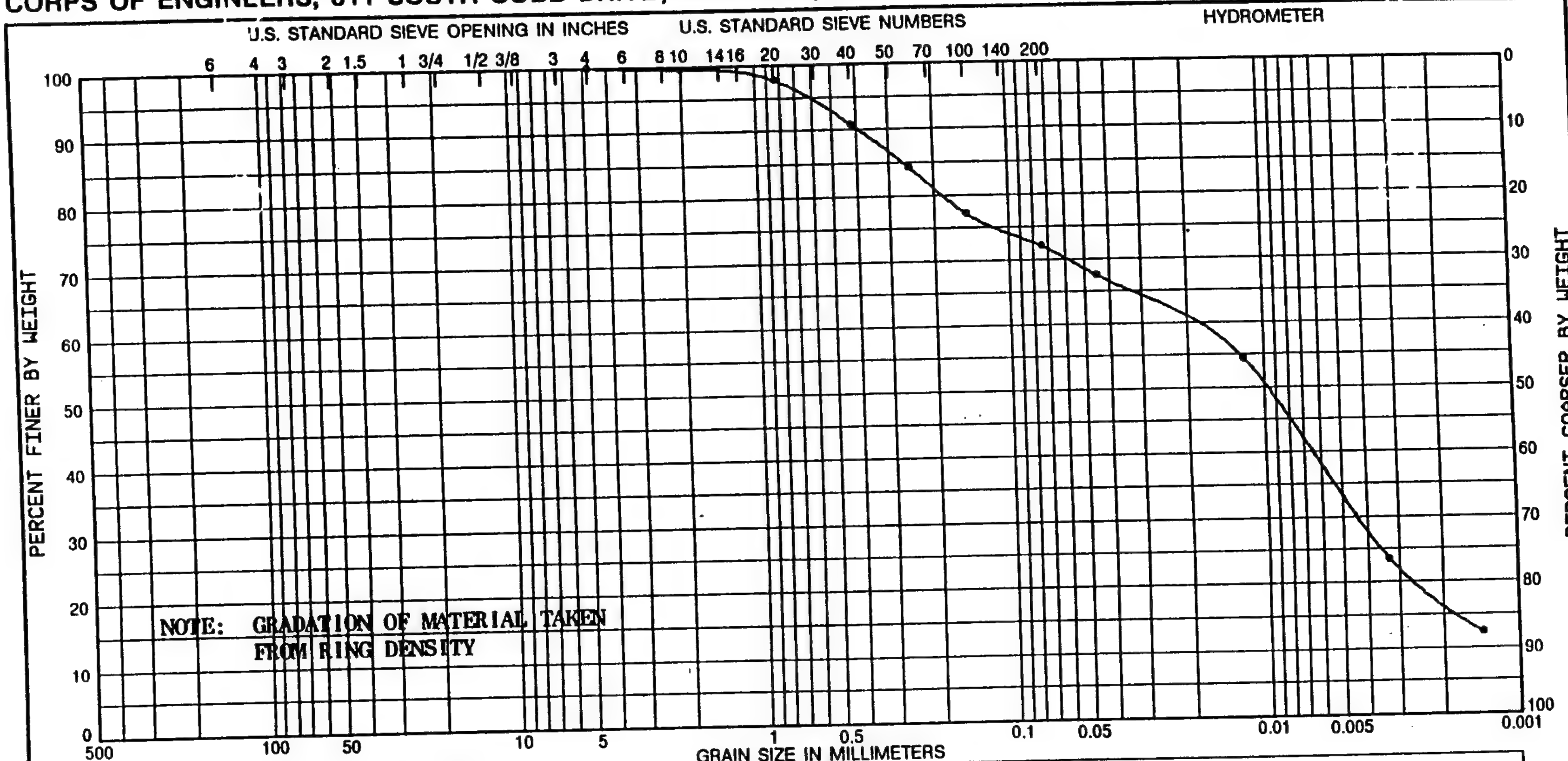
Project: *VIBRACORE SEDIMENT SAMPLES*	Boring No. *NJV-128*
Location: *OFFSHORE OF NEW JERSEY*	Lab No 184/955
Boring Depth (ft): *18.20* — Elevation: ——	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*	Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A LITTLE GRAVEL SIZES.	
	1		DK. GRAY, FAT CLAY (CH), WITH SOME SAND AND A TRACE OF MICA.	
	2			
	3			A -2.4/-2.8 WET DEN. = 107.5, DRY DEN. = 80.2, M. C. = 34.1%
	4		GRAY, SILTY SAND (SM), WITH PLASTIC FINES AND A TRACE OF ORGANICS.	SA -3.7/-4.0
-5	5		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH SOME GRAVEL SIZES.	
	6			
	7			B -6.7/-7.1 WET DEN. = 122.1, DRY DEN. = 114.1, M. C. = 7.0%
	8			
	9			
-10	10			
	11			
	12		TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES.	C -11.5/-12.0 WET DEN. = 123.7, DRY DEN = 117.4, M. C. = 5.4%
	13			
	14			
-15	15			
	16			
	17			D -16.4/-16.8 WET DEN = 120.7, DRY DEN. = 112.6, M. C. = 7.2%
	18			
	19			
-20				

Date: *04/19/94* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev	Classification	Nat w%	LL	PL	PI
1	-2.4 / -2.8'	(VISUAL) DK. GRAY, FAT CLAY (CH), WITH	34.1			
		SOME SAND SIZES AND A TRACE OF MICA.				
		SP. GRAVITY = 2.72				
		WET DEDSITY = 107.5 PCF.				
		DRY DENSITY = 80.2 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/855A

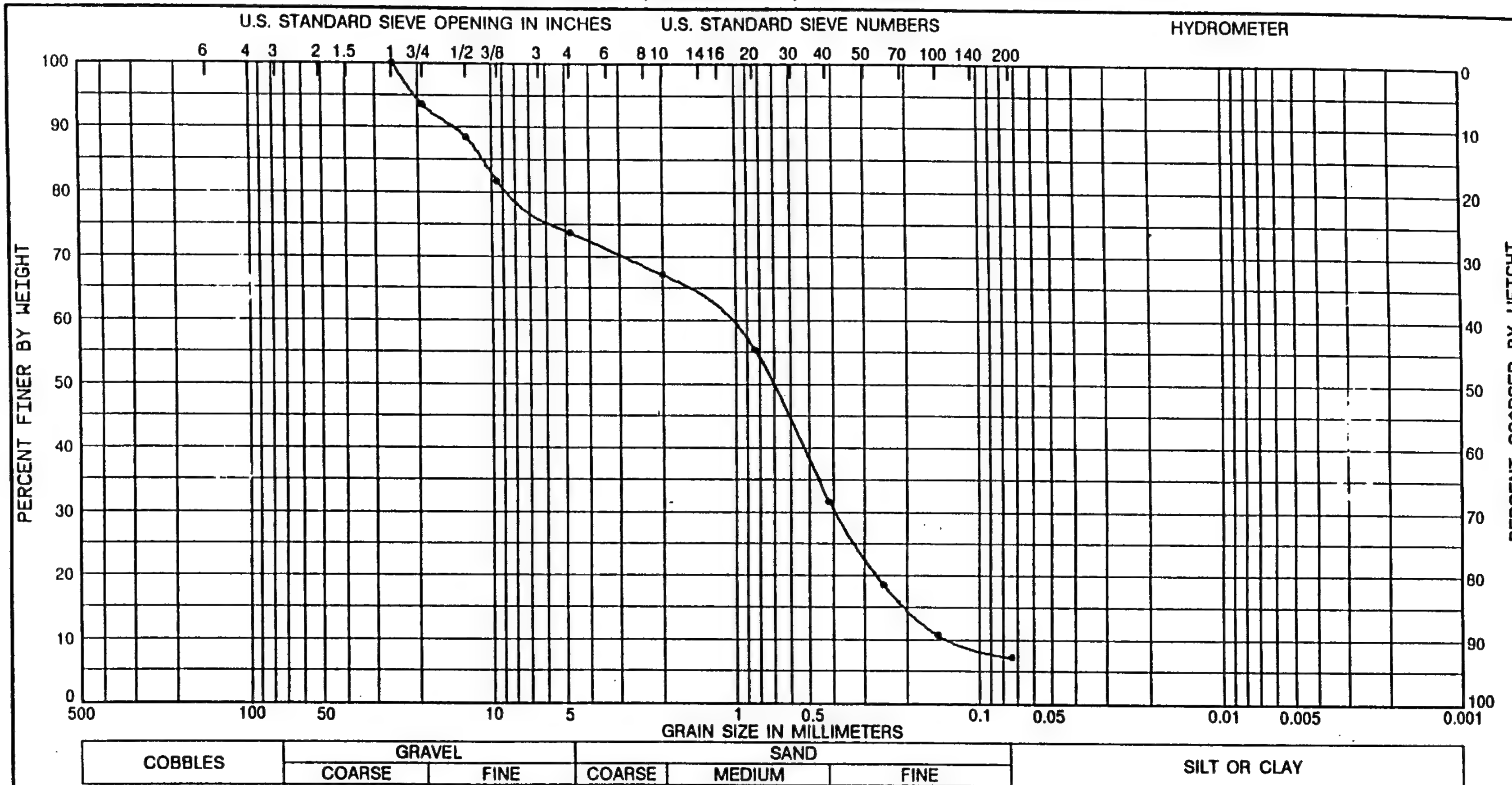
Boring No. NJV-128

Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



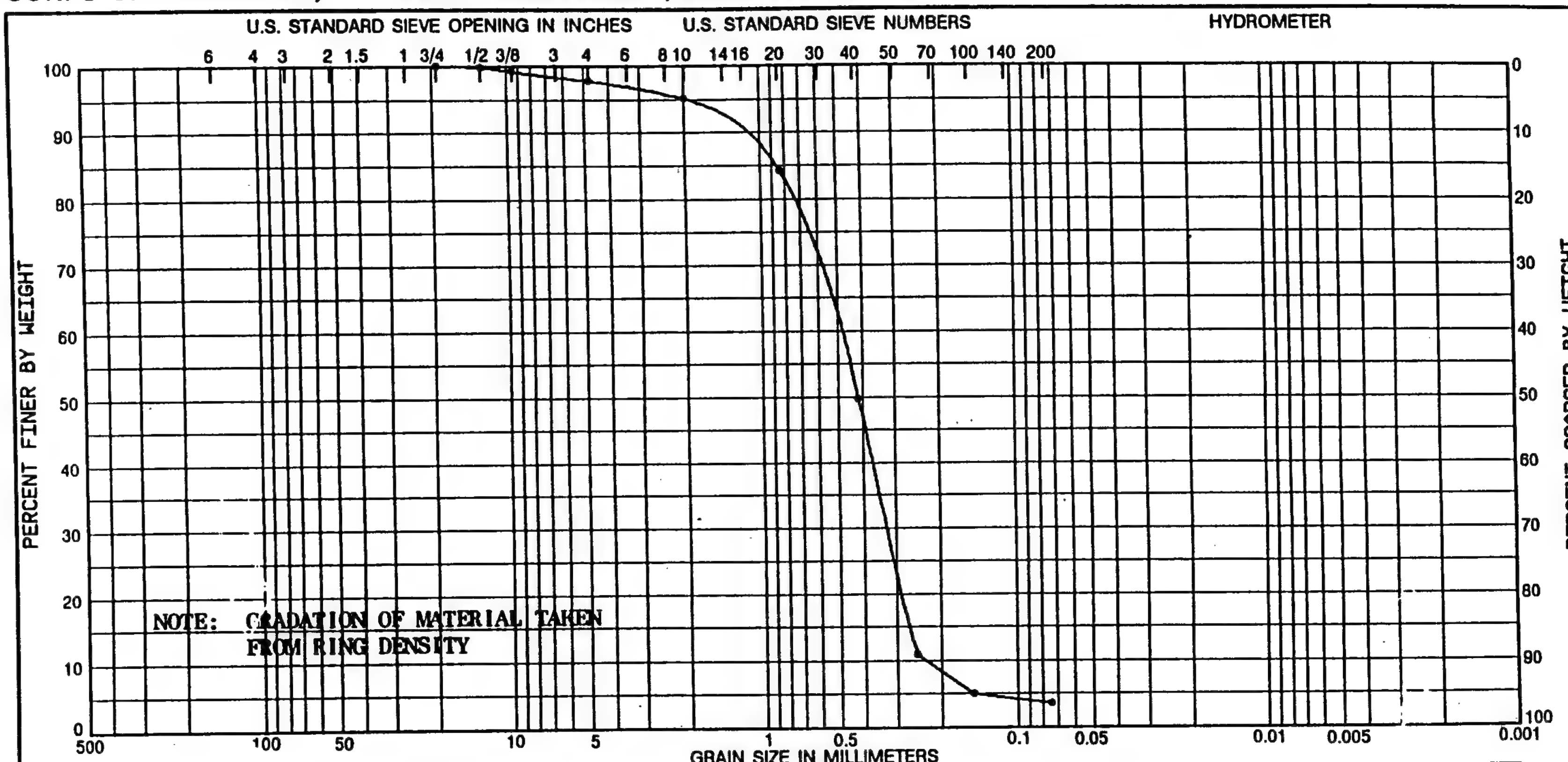
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 3.7 / - 4.0'	(VISUAL) GRAY POORLY GRADED SILTY SAND				
		(SP-SM), WITH SOME GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/855
Boring No. NJV-128
Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

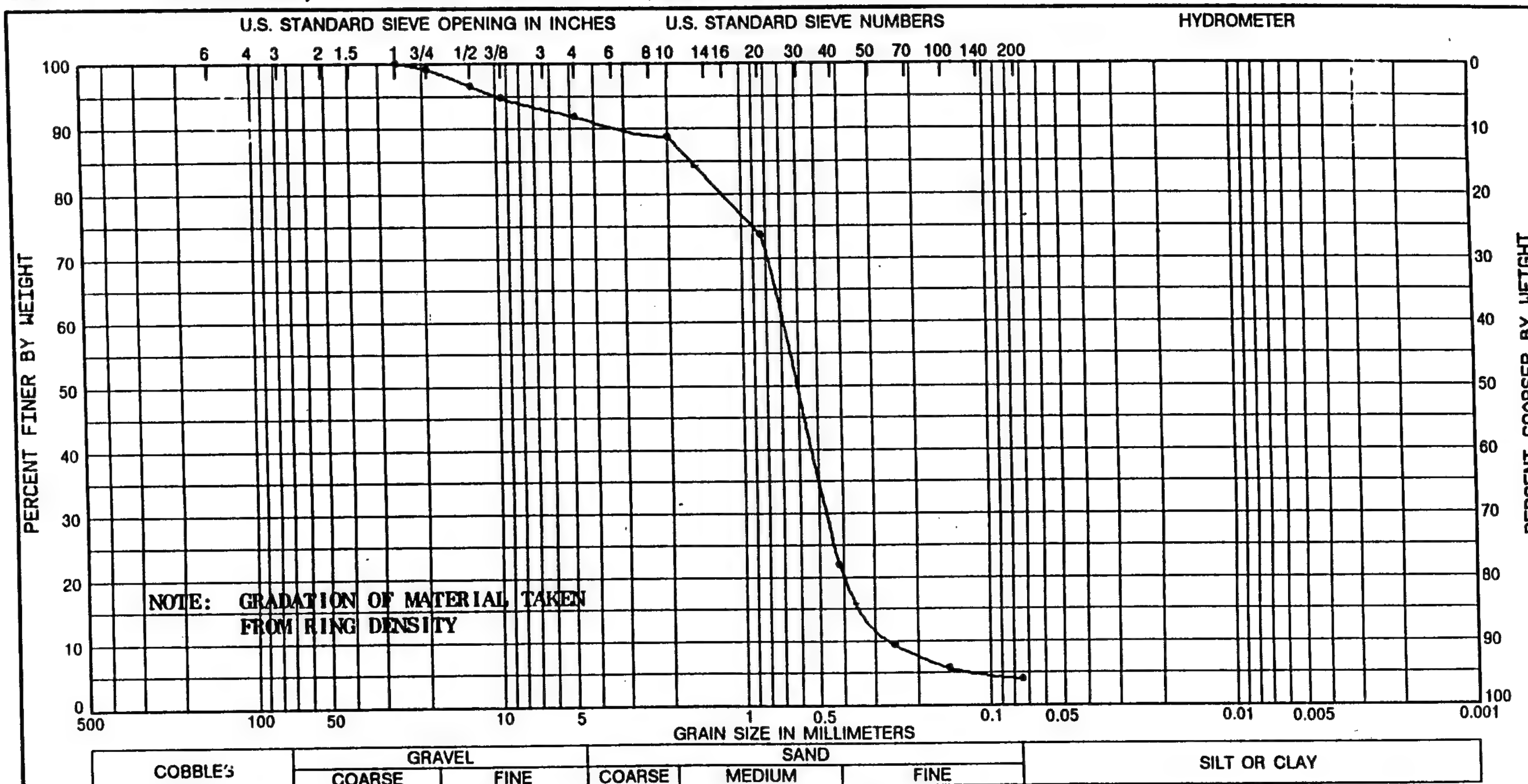
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-6.7 / -7.1'	(VISUAL) TAN, POORLY GRADED SAND (SP),	7.0			
		WITH A TRACE OF GRAVEL SIZES.				
		SP. GRAVITY = 2.66				
		WET DENSITY = 122.1 PCF.				
		DRY DENSITY = 114.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/855B
Boring No. NJV-128
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-11.5 / -12.0'	(VISUAL) TAN, POORLY GRADED SAND (SP),	5.4			
		WITH A TRACE OF GRAVEL SIZES.				
		SP. GRAVITY = 2.67				
		WET DENSITY = 123.7.				
		DRY DENSITY = 117.4 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/855C

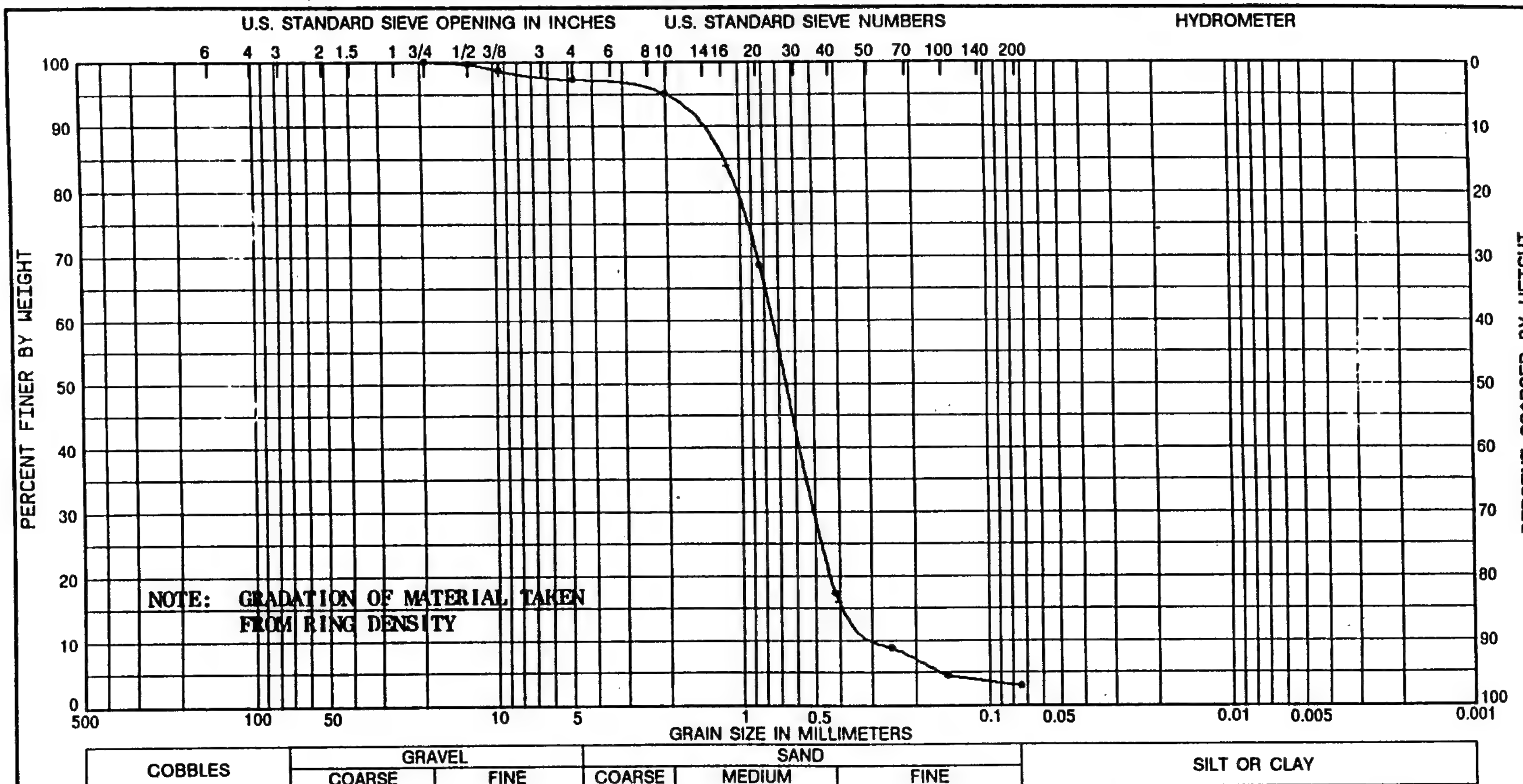
Boring No. NJV-128

Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-16.4 / -16.8'	(VISUAL) TAN, POORLY GRADED SAND (SP),	7.2			
		WITH A TRACE OF GRAVEL SIZES.				
		SP. GRAVITY = 2.64				
		WET DENSITY = 120.7 PCF.				
		DRY DENSITY = 112.6 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/855D
Boring No. NJV-128
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

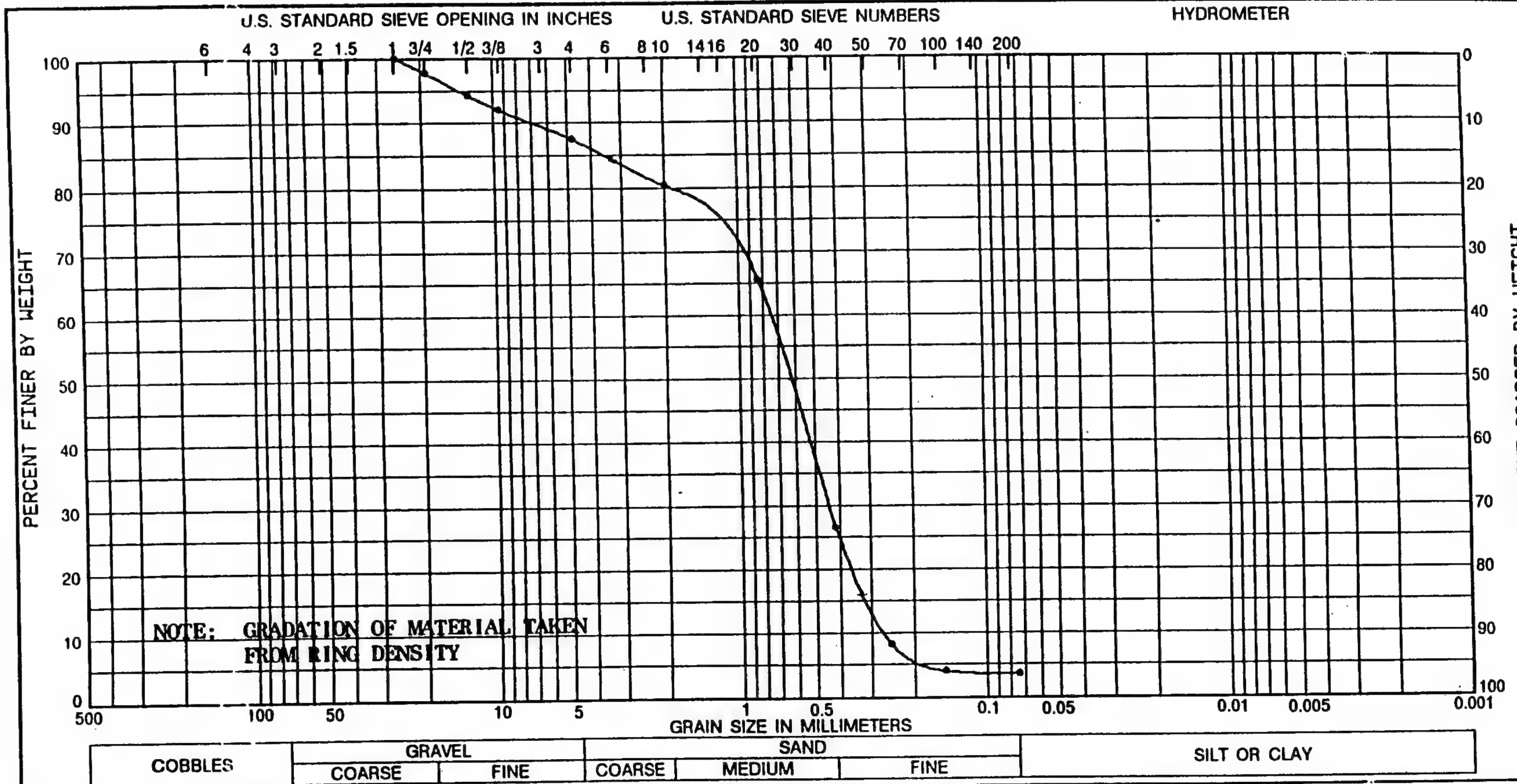
Project: *VIBRACORE SEDIMENT SAMPLES*		Boring No. *NJV-129*
Location: *OFFSHORE OF NEW JERSEY*		Lab No. *184/856*
Boring Depth (ft): *17.50*	Elevation: ——	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*		Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0				
	1			
	2		LT. GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A LITTLE GRAVEL SIZES.	A -1.5/-1.9 WET DEN. = 132.5, DRY DEN. = 123.1, M. C. = 7.6%
	3			
	4		--	
-5	5		LT. GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH SOME GRAVEL SIZES.	SA -5.3/-5.8
	6		--	B -6.4/-6.8 WET DEN. = 119.5, DRY DEN. = 111.4, M. C. = 7.2%
	7			
	8			
	9			
-10	10			
	11		LT. GRAY. POORLY GRADED SILTY SAND (SP-SM), WITH A LITTLE GRAVEL SIZES.	C -11.0/-11.4 WET DEN. = 126.1, DRY DEN. = 110.1, M. C. = 14.5%
	12			
	13			
	14			
-15	15			
	16			D -16.0/-16.4 WET DEN. = 118.8, DRY DEN. = 107.6, M. C. = 10.4%
	17		--	

Date: *04/19/94* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-1.5 / -1.9'	(VISUAL) LT. GRAY, POORLY GRADED SAND	7.6			
		(SP), WITH A LITTLE GRAVEL SIZES.				
		SP. GRAVITY = 2.67				
		WET DENSITY = 132.5 PCF.				
		DRY DENSITY = 123.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/856A

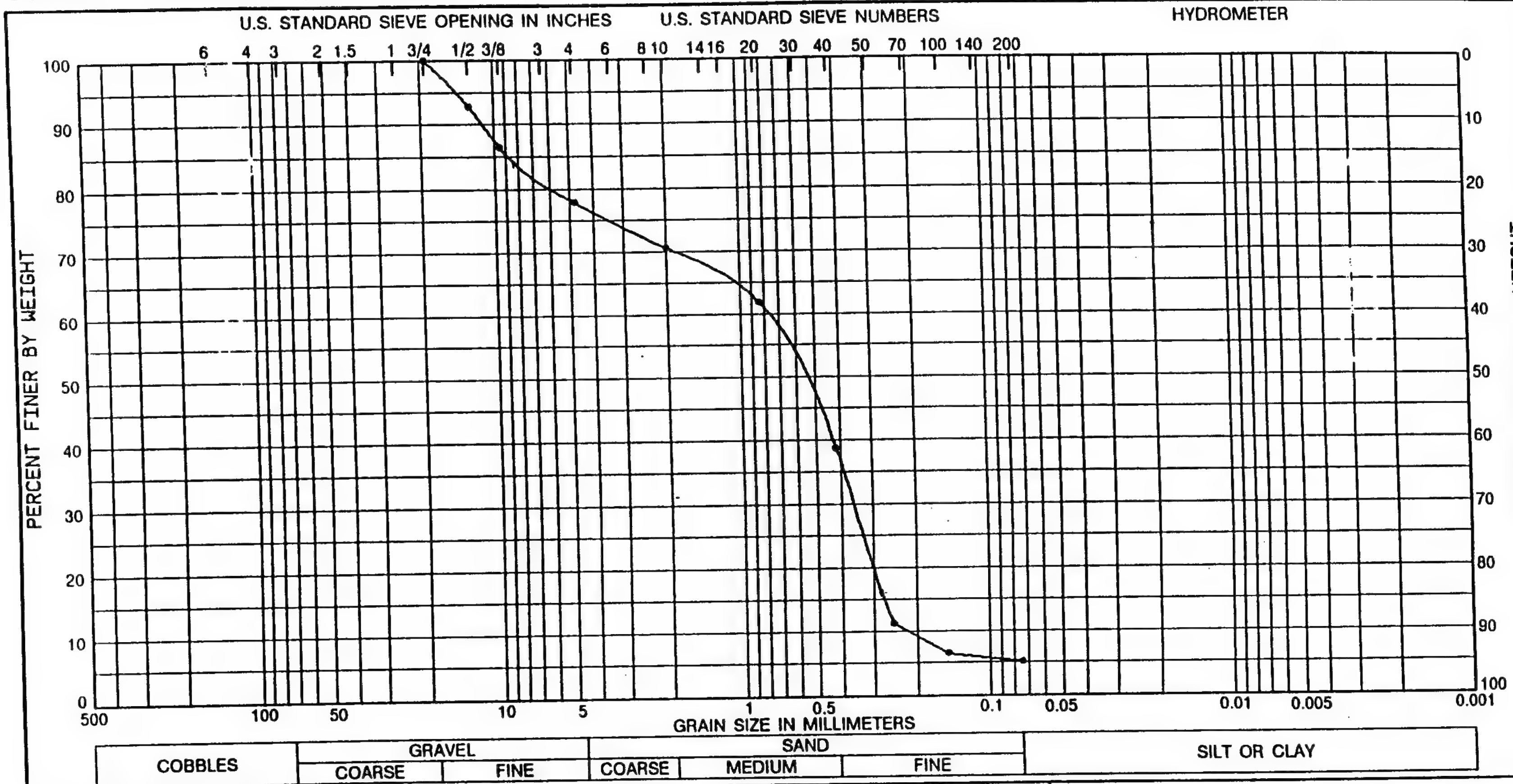
Boring No. NJV-129

Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



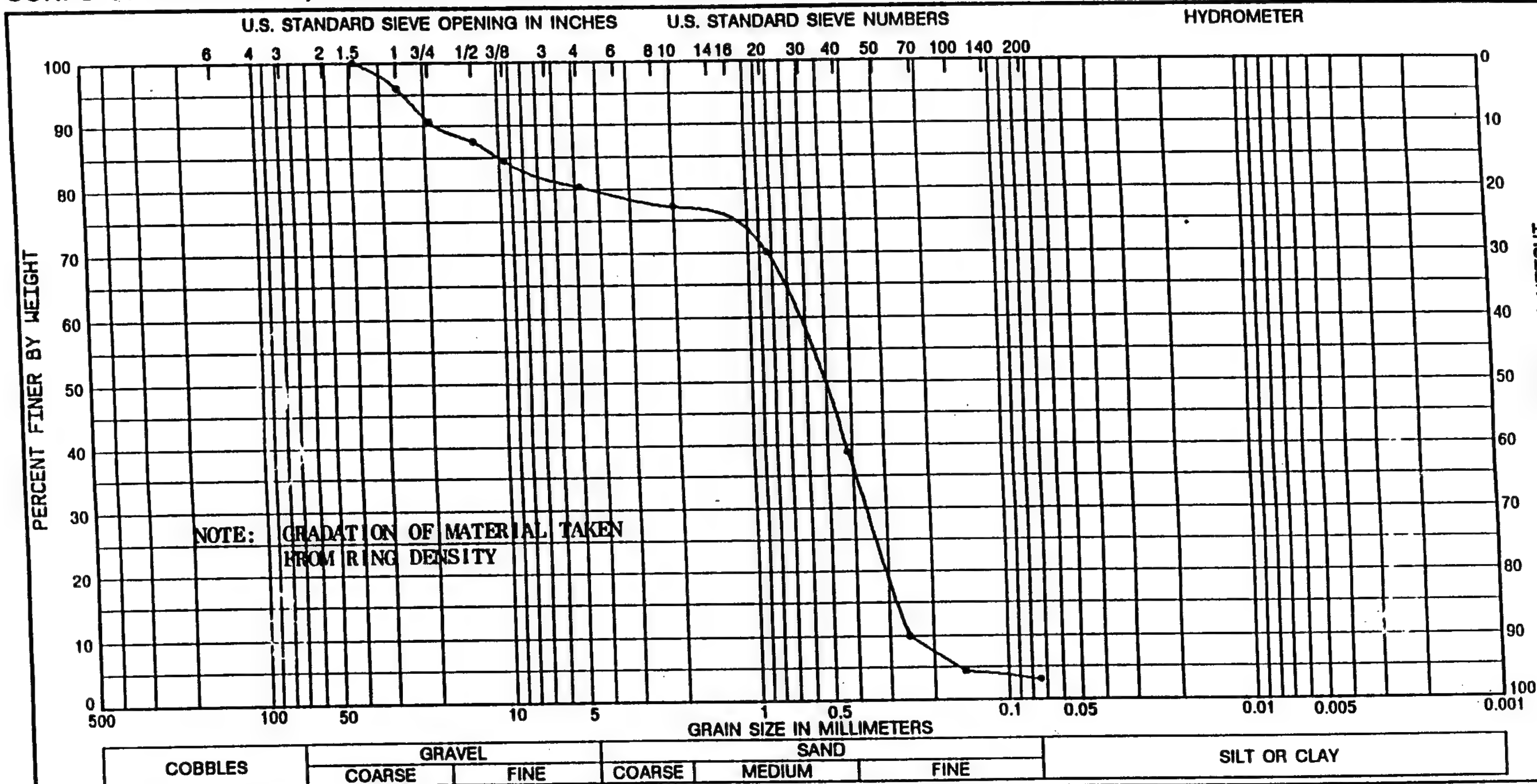
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 5.3 / - 5.8'	(VISUAL) LT. GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH SOME GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/856
Boring No. NJV-129
Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-6.4 / -6.8'	(VISUAL) LT. GRAY, POORLY GRADED	7.2			
		SAND (SP), WITH A LITTLE GRAVEL SIZES.				
		SP. GRAVITY = 2.67				
		WET DENSITY = 119.5 PCF.				
		DRY DENSITY = 111.5 pcf				

Project VIBRACORE SEDIMENT SAMPLES OFFSHORE OF NEW JERSEY

Lab No. 184/8568

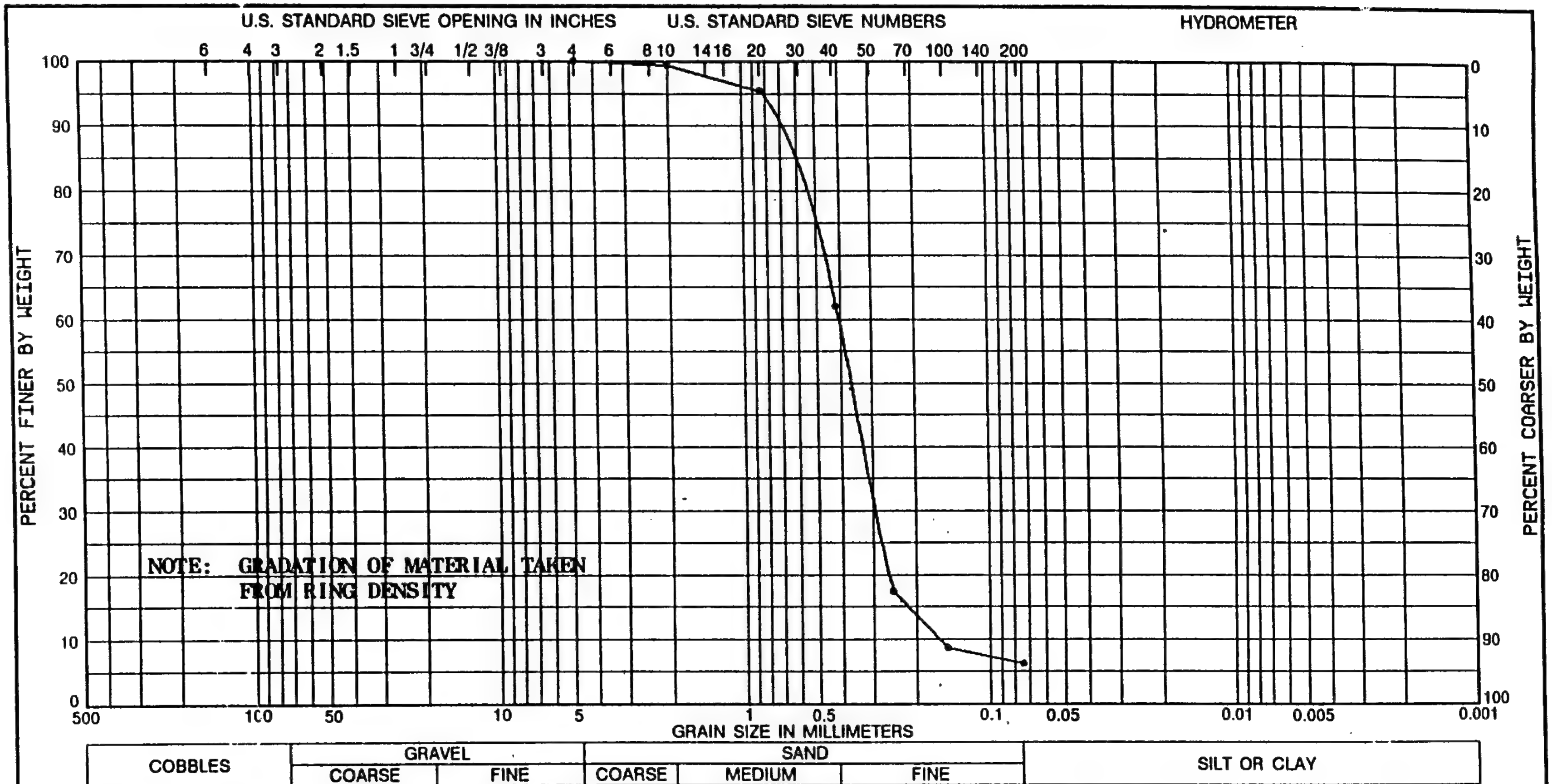
Boring No. NJV-129

Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



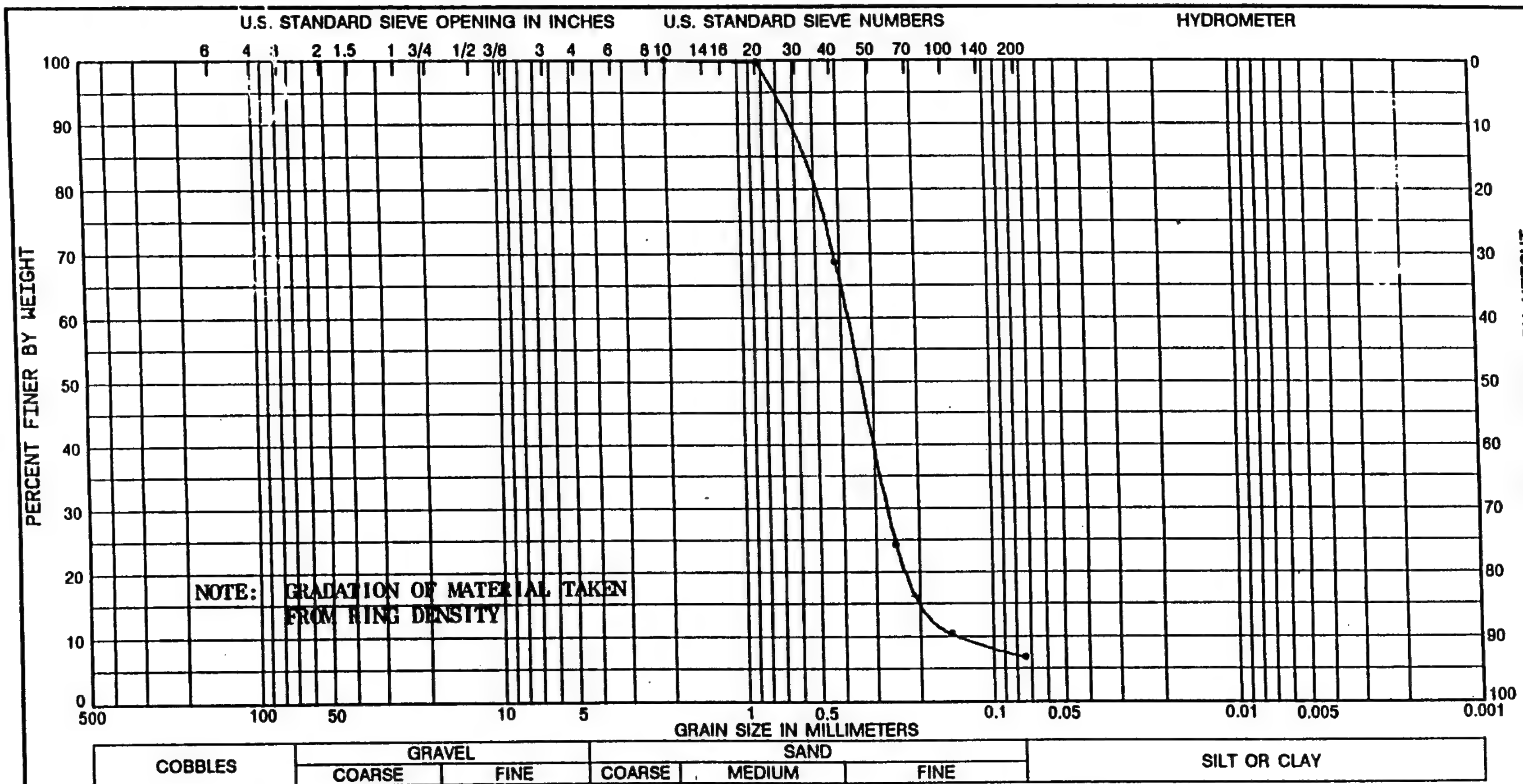
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-11.0 / -11.4'	(VISUAL) LT. GRAY POORLY GRADED SILTY	14.5			
		SAND (SP-SM).				
		SP. GRAVITY = 2.64				
		WET DENSITY = 126.1 PCF.				
		DRY DENSITY = 110.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/856C
Boring No. NJV-129
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-16.0/-16.4	(VISUAL) LT. GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF MICA. SP. GRAVITY = 2.67 WET DENSITY = 118.8 PCF. DRY DENSITY = 107.6 PCF.	10.4			

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/856D
Boring No. NJV-129
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

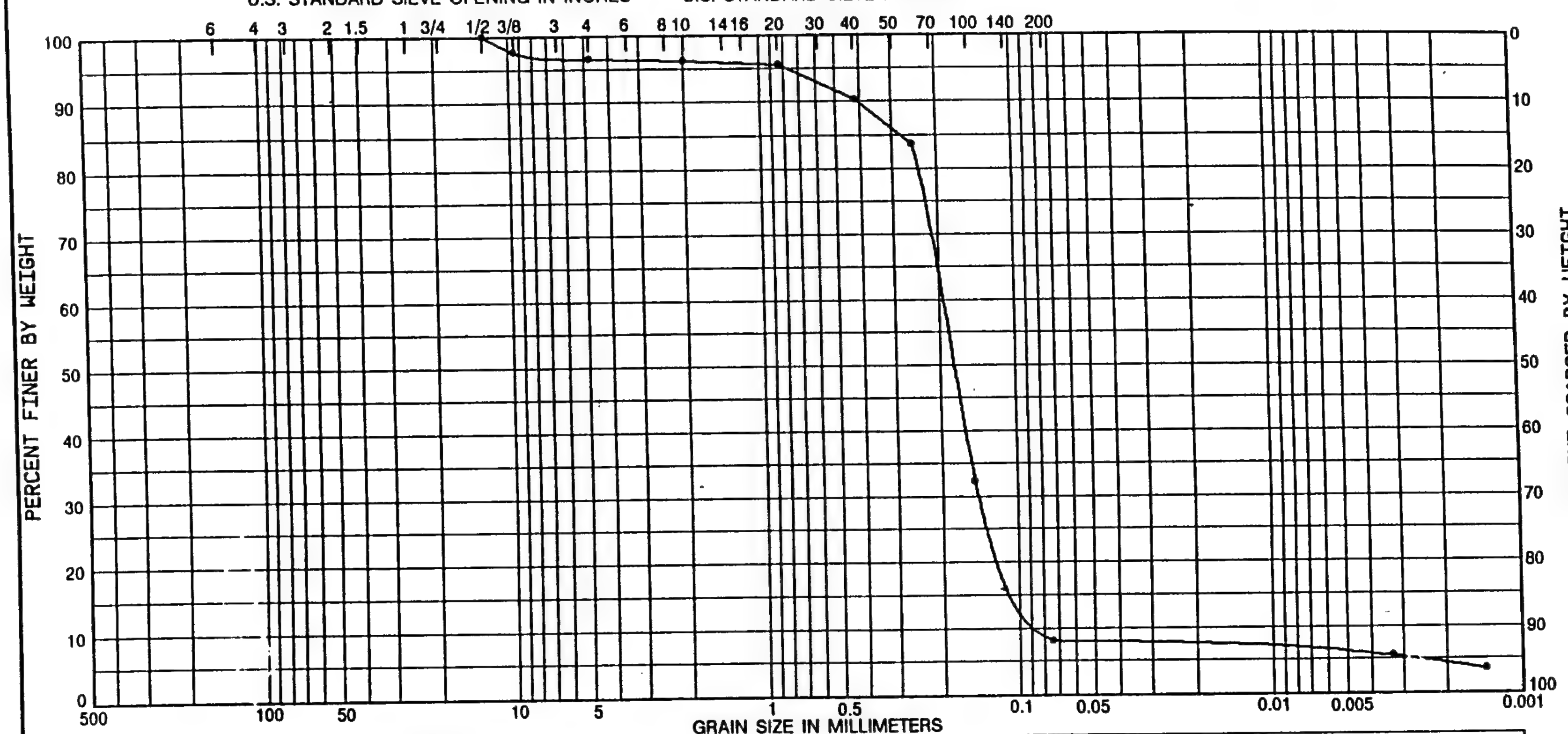
Project: *VIBRACORE SEDIMENT SAMPLES*		Boring No. *NJV-130*
Location: *OFFSHORE OF NEW JERSEY*		Lab No. *184/857*
Boring Depth (ft): *19.40*	Elevation:———	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*		Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0–2		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH PLASTIC FINES AND A TRACE OF SAND SIZES AND MICA.	MA -0.7/-1.0
	3			A -3.0/-3.4 WET DEN. = 115.5, DRY DEN. = 84.9, M. C. = 36.1%
-5	5			
	8			B -8.0/-8.4 WET DEN. = 103.1, DRY DEN. = 67.5, M. C. = 52.8%
	9		DK. GRAY, FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND MICA.	
-10	10			
	12			C -12.0/-12.4 WET DEN. = 104.0, DRY DEN. = 69.1, M. C. = 52.9%
-15	15			
	17			D -17.0/-17.5 WET DEN. = 105.5, DRY DEN. = 70.1, M. C. = 50.5%
-20	19			

Date: *04/19/94* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

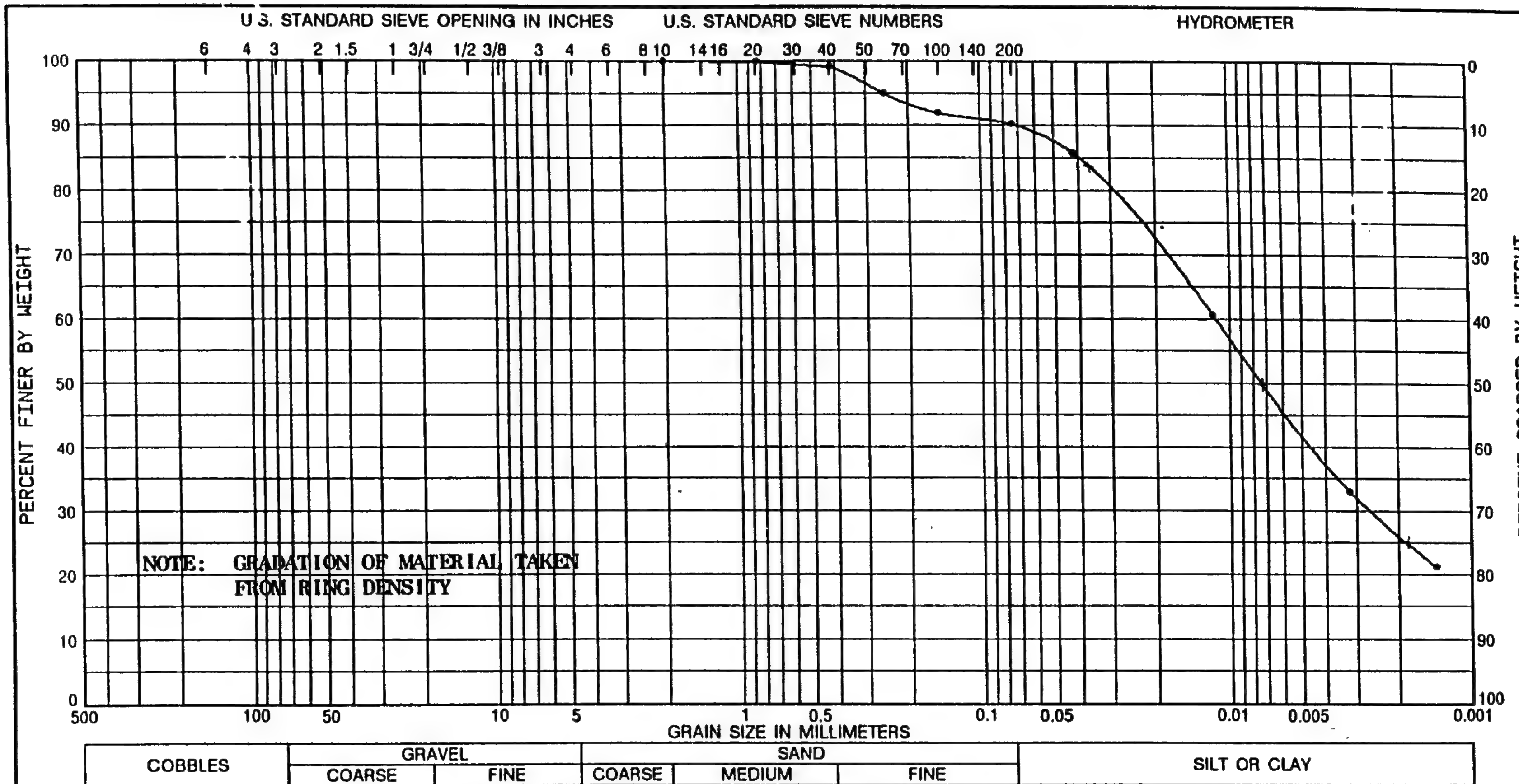
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	- 0.7 / - 1.0'	(VISUAL) GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/857
Boring No. NJV-130
Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



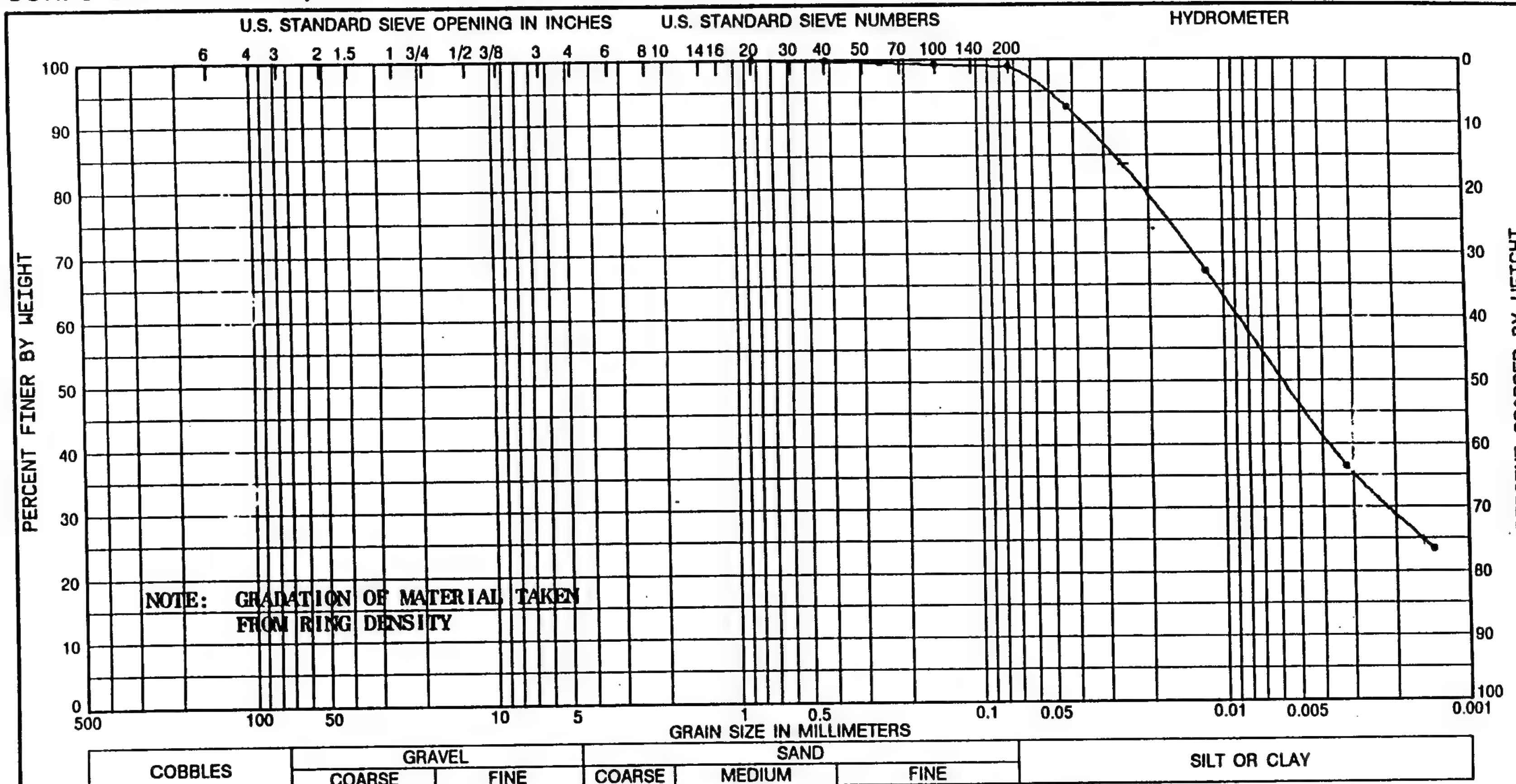
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-3.0 / -3.4'	(VISUAL) DK. GRAY, FAT CLAY (CH), WITH	36.1			
		A TRACE OF SAND AND MICA.				
		SP. GRAVITY = 2.72				
		WET DENSITY = 115.5 PCF.				
		DRY DENSITY = 84.9 PCF.				

GRADATION CURVES

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/857A
Boring No. NJV-130
Date 04/07/94

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



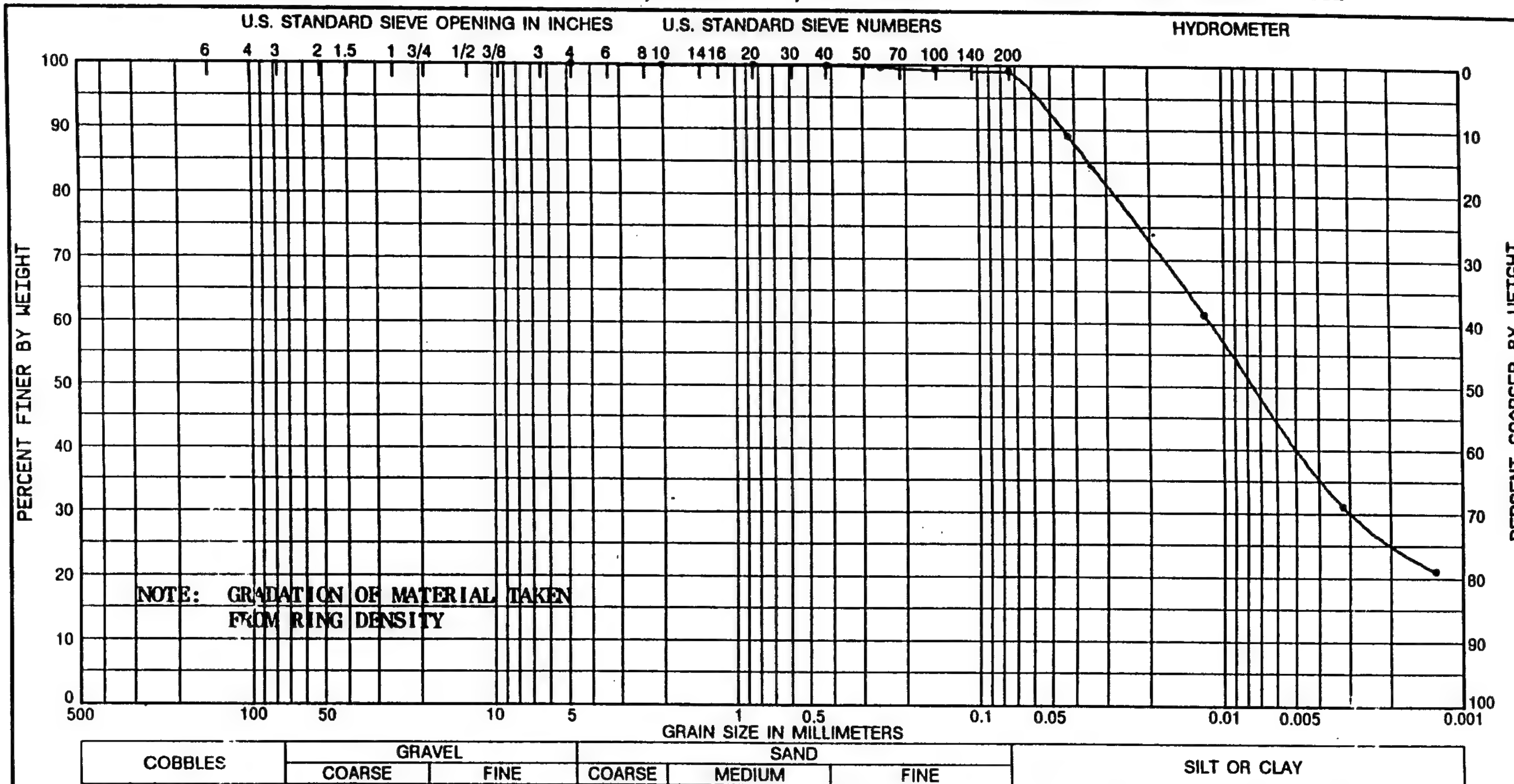
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-8.0 / -8.4'	(VISUAL) DK. GRAY, FAT CLAY (CH), WITH	52.8			
		A TRACE OF MICA.				
		SP. GRAVITY = 2.71				
		WET DENSITY = 103.1 PCF.				
		DRY DENSITY = 67.5 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/857B
Boring No. NJV-130
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



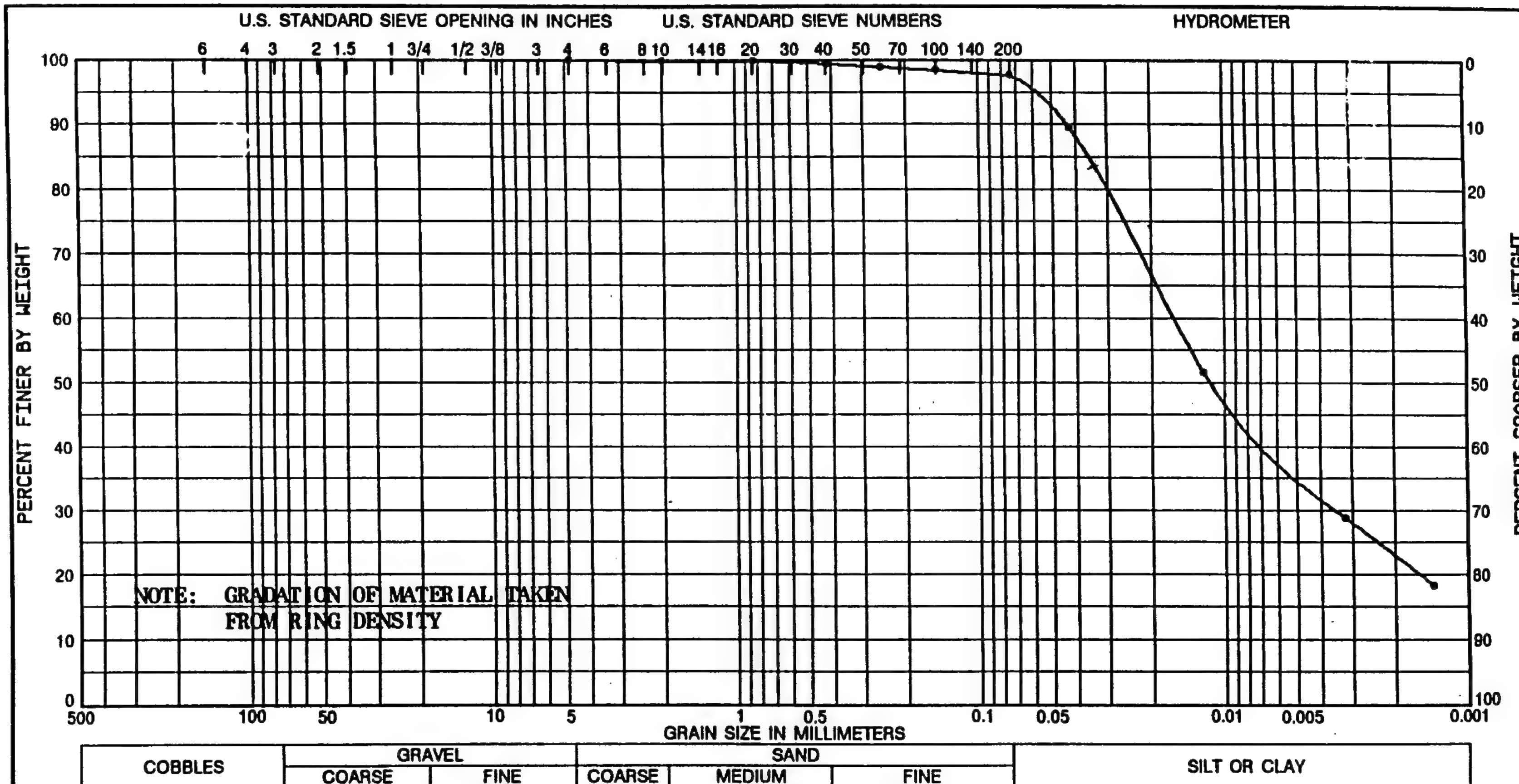
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-12.0 / -12.4'	(VISUAL) GRAY, FAT CLAY (CH), WITH A	52.9			
		TRACE OF MICA.				
		SP. GRAVITY = 2.70				
		WET DENSITY = 104.0 PCF.				
		DRY DENSITY = 69.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/857C
Boring No. NJV-130
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-17.0 / -7.5'	(VISUAL) GRAY, FAT CLAY (CH), WITH	50.5			
		A TRACE OF SAND SIZES AND MICA.				
		SP. GRAVITY = 2.70				
		WET DENSITY = 105.5 PCF.				
		DRY DENSITY = 70.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/857D

Boring No. NJV-130

Date 04/20/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

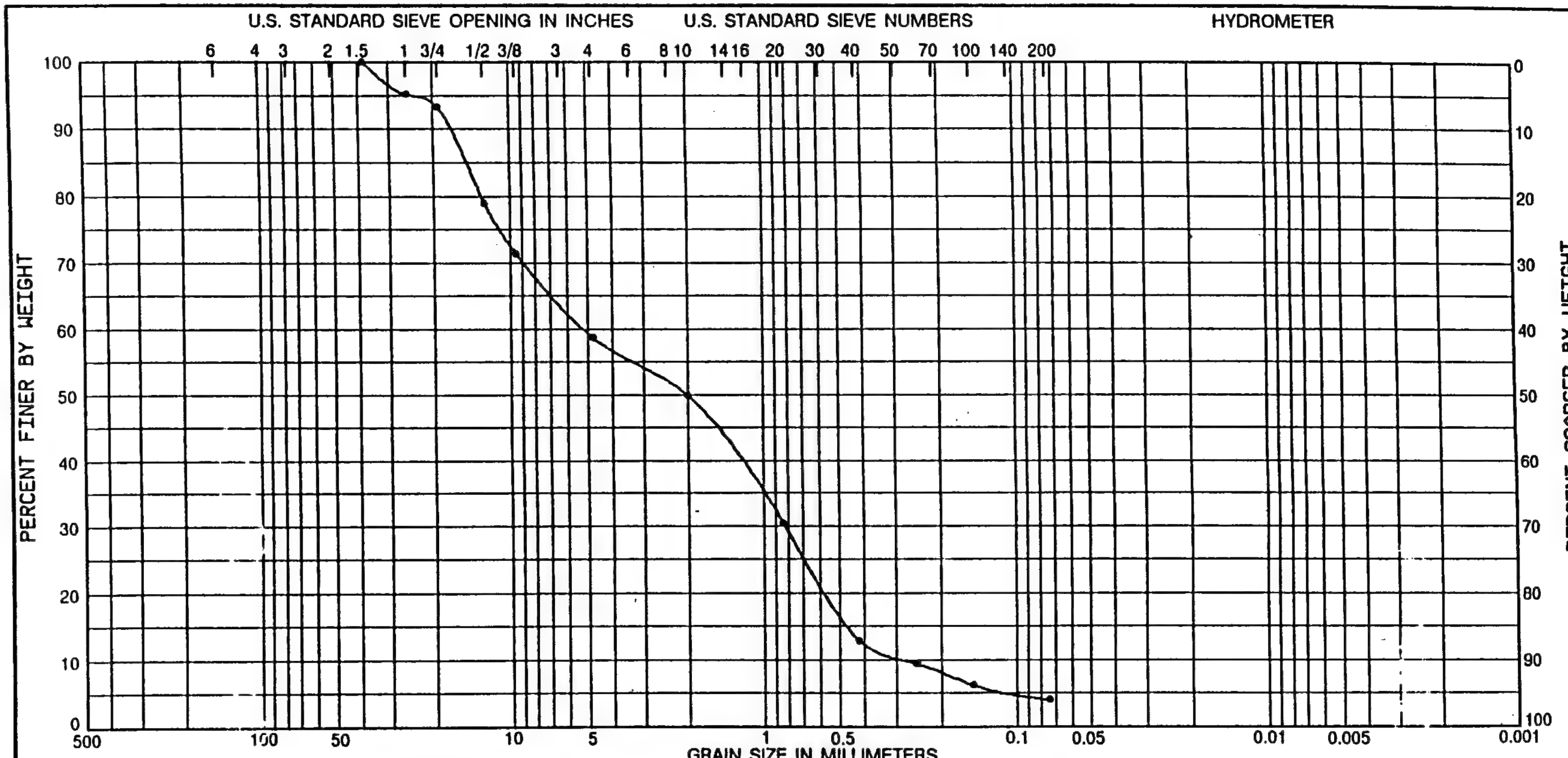
Project: *VIBRACORE SEDIMENT SAMPLES*		Boring No. *NJV-131*
Location: *OFFSHORE OF NEW JERSEY*		Lab No. *184/858*
Boring Depth (ft): *19.00*	Elevation: ——	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*		Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0–2.6		LT. GRAY, GRAVELLY POORLY GRADED SAND (SP).	SA -1.0/-1.3
	2.6–4.8		TANNISH GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.	A -2.6/-3.0 WET DEN. = 129.1, DRY DEN. = 113.4, M. C. = 13.8%
-5	4.8–10.2		TAN, POORLY GRADED SAND (SP), WITH A LITTLE GRAVEL SIZES.	B -7.0/-7.4 WET DEN. = 127.3, DRY DEN. = 121.6, M. C. = 4.7%
-10	10.2–13.2		TAN, POORLY GRADED SILTY SAND (SP-SM).	C -12.0/-12.4 WET DEN. = 121.2, DRY DEN. = 111.6, M. C. = 8.6%
-15	13.2–19.0		TAN, POORLY GRADED SAND (SP).	D -17.0/-17.4 WET DEN. = 125.4, DRY DEN. = 111.1, M. C. = 12.9%
-20				

Date: *04/19/94* **LABORATORY LOG AND SAMPLE DATUM** Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	- 1.0 / - 1.3'	(VISUAL) LT. GRAY, GRAVELLY POORLY GRADED SAND (SP).				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/858

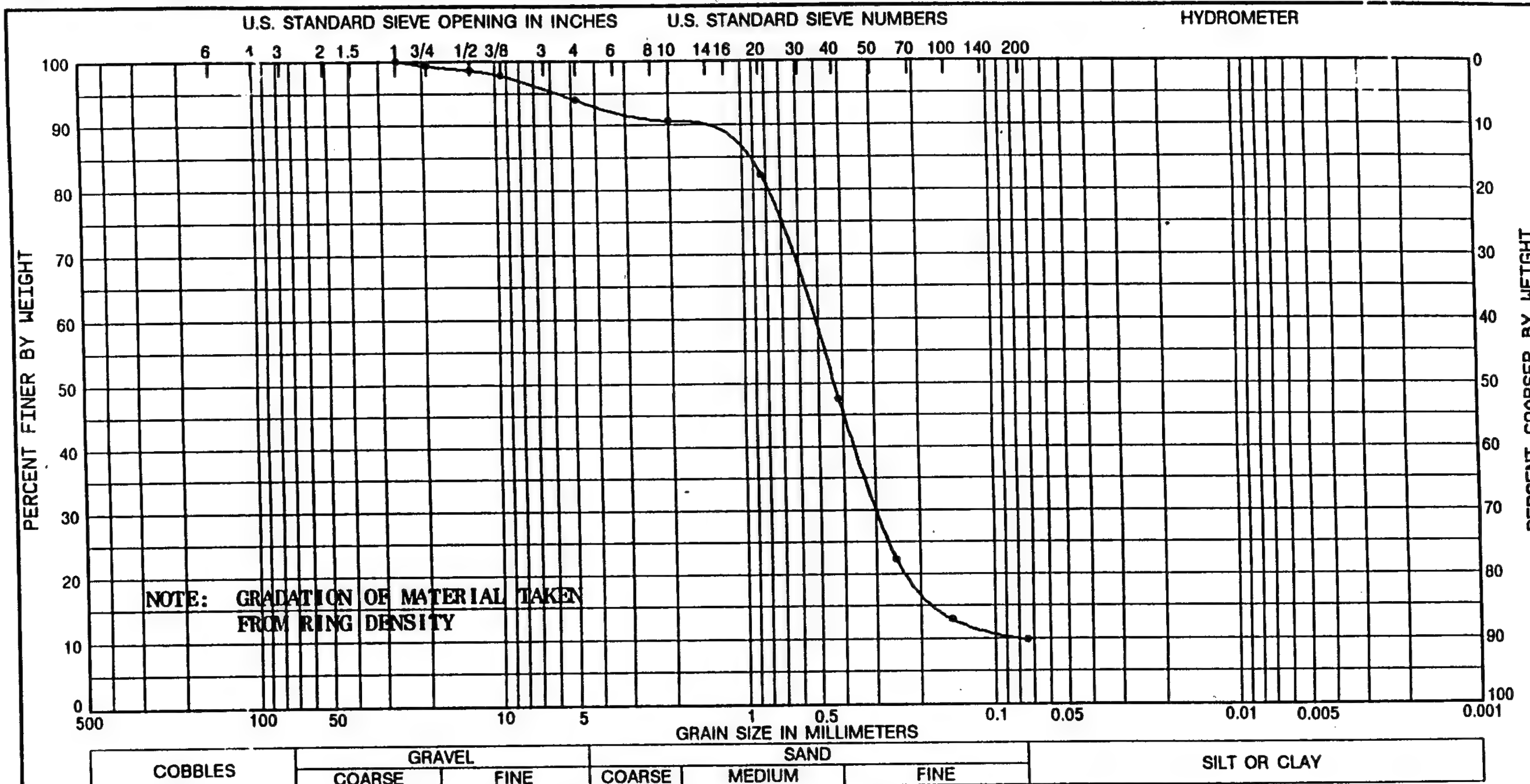
Boring No. NJV-131

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



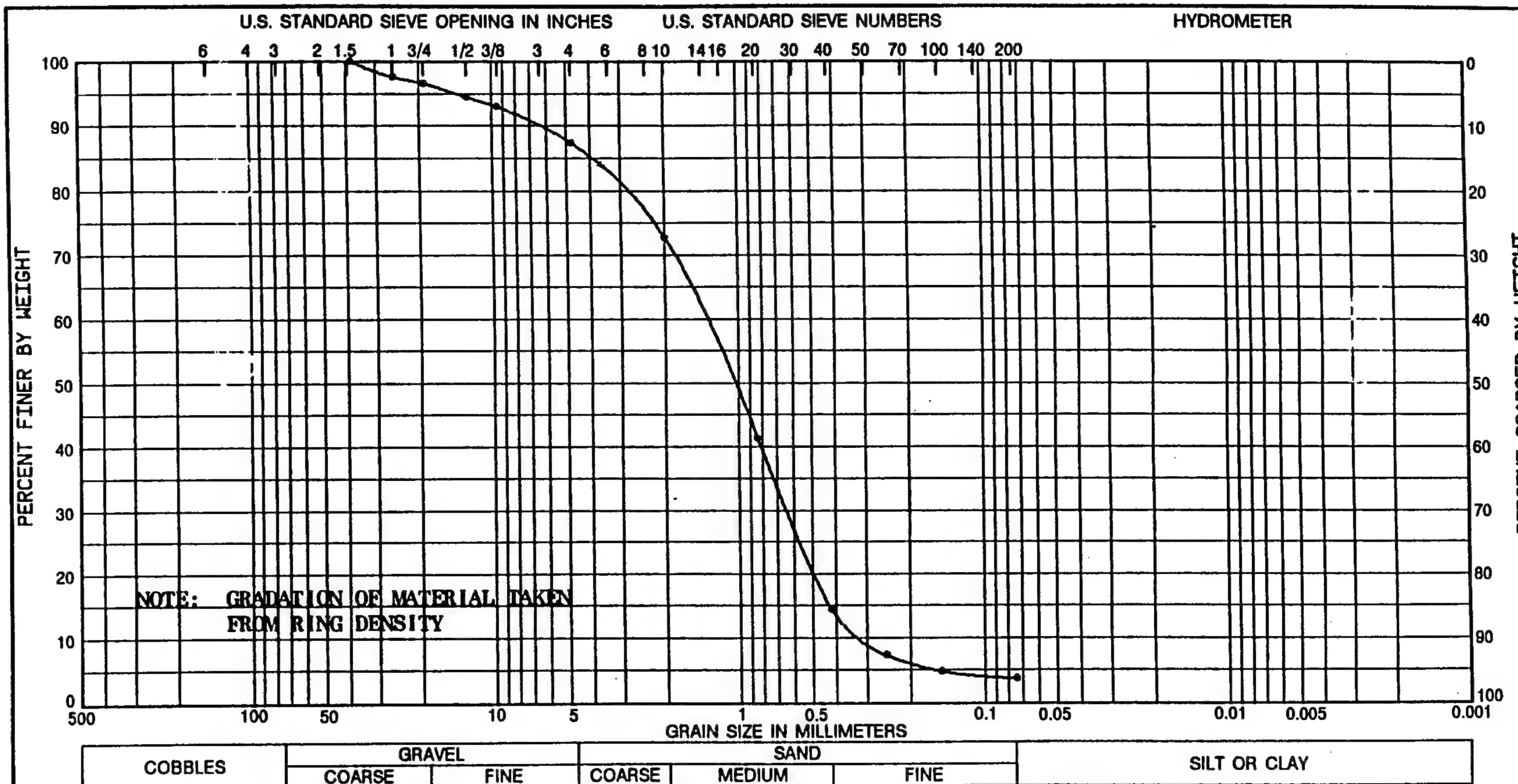
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-2.6 / -3.0'	(VISUAL) TANNISH GRAY, POORLY GRADED	13.8			
		SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL.				
		SP. GRAVITY = 2.67				
		WET DENSITY = 129.1 PCF. 2.07				
		DRY DENSITY = 113.4 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/858A
Boring No. NJV-131
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



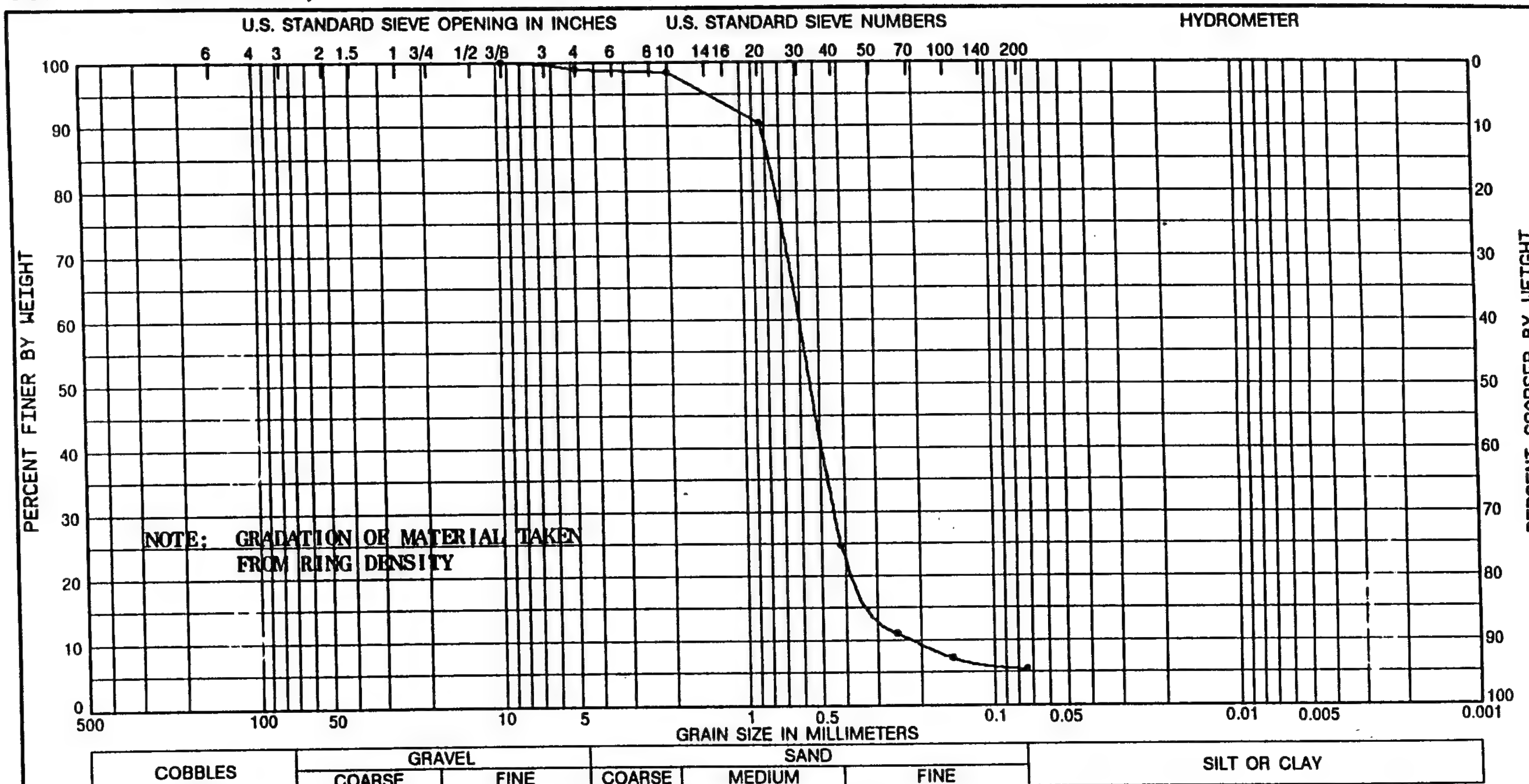
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-7.0 / -7.4'	(VISUAL) TAN, POORLY GRADED SAND (SP),	4.7			
		WITH A LITTLE GRAVEL SIZES.				
		SP. GRAVITY = 2.65				
		WET DENSITY = 127.3 PCF. 2.04				
		DRY DENSITY = 121.6 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/8588
Boring No. NJV-131
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



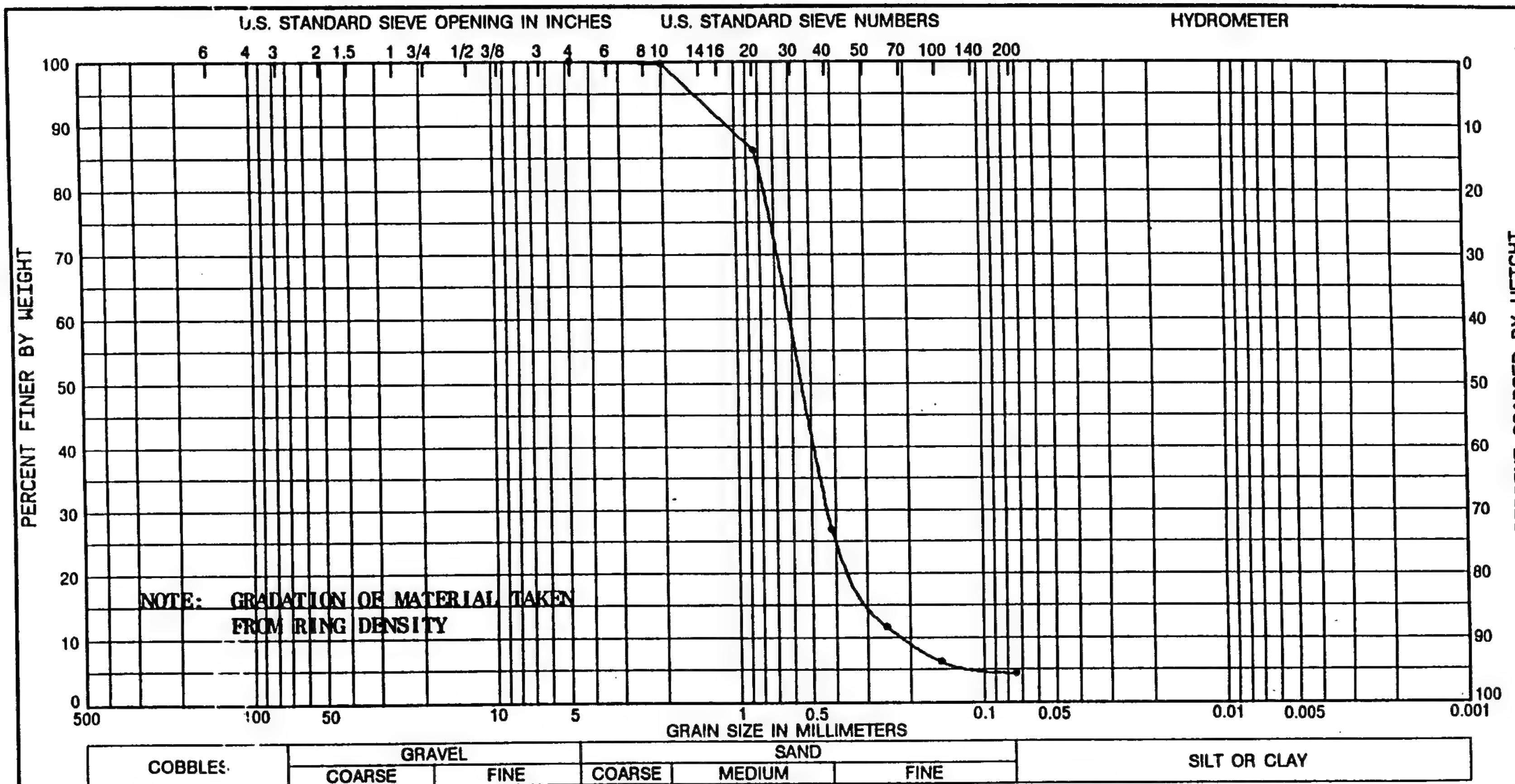
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3.	-12.0 / -12.4'	(VISUAL) TAN, POORLY GRADED SILTY SAND	8.6			
		(SP-SM).				
		SP. GRAVITY = 2.64				
		WET DENSITY = 121.2 PCF.				
		DRY DENSITY = 111.6 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/858C
Boring No. NJV-131
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-17.0 / -17.4'	(VISUAL) TAN, POORLY GRADED SAND (SP).	12.9			
		SP. GRAVITY = 2.64				
		WET DENSITY = 125.4 PCF.				
		DRT DENSITY = 111.1 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/858D
Boring No. NJV-131
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

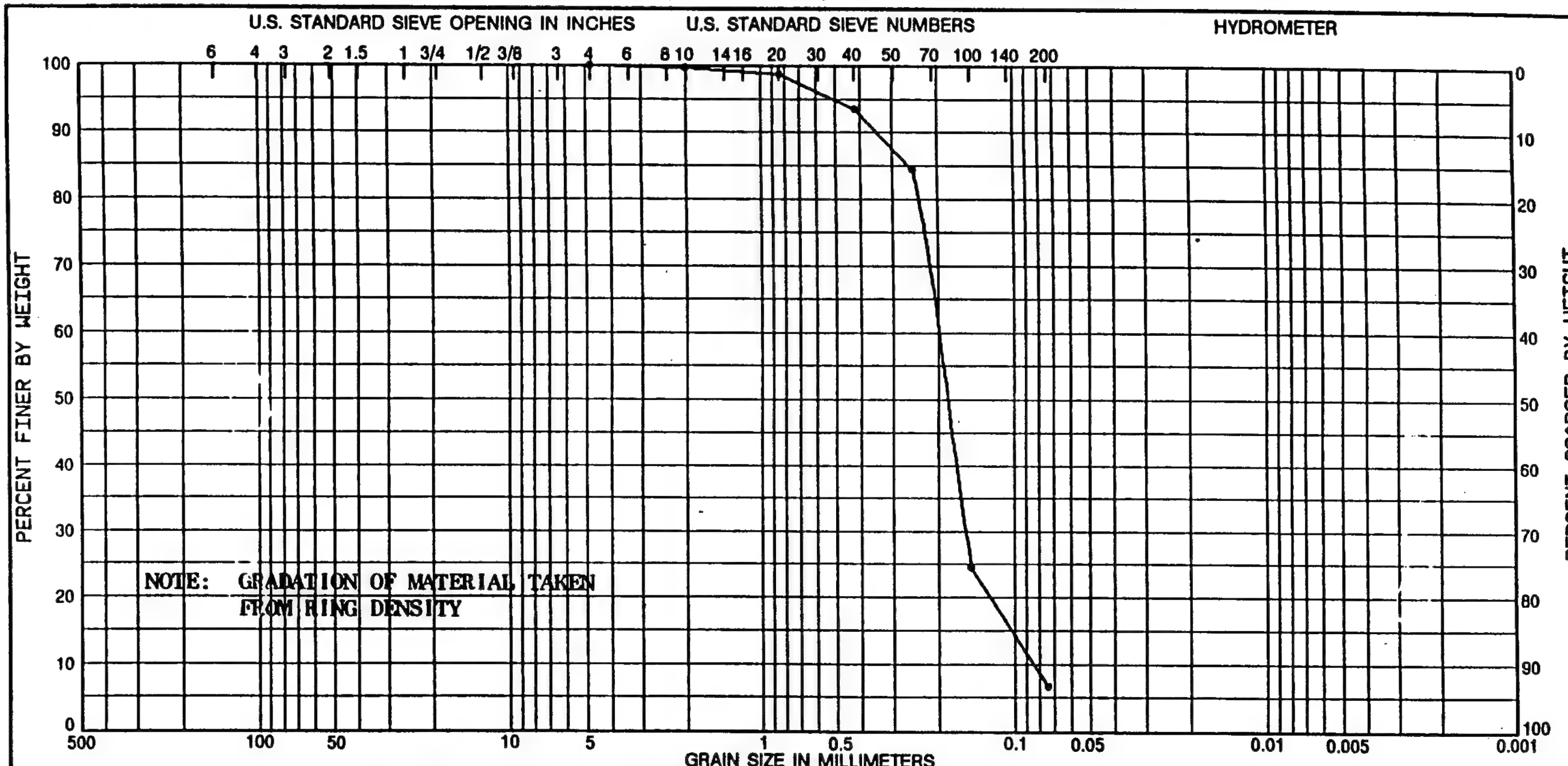
Project: VIBRACORE SEDIMENT SAMPLES	Boring No. NJV-132
Location: OFFSHORE OF NEW JERSEY	Lab No. 184/859
Boring Depth (ft): 14.00 — Elevation: ——	Work order: 7185
Datum/Notes: See grain size data on enclosed gradation curves.	Requisition: NAPEN-94-612

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0				
	1			
	2		GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF SHELL FRAGMENTS.	A -2.1/-2.5 WET DEN. = 127.8, DRY DEN. = 107.0, M. C. = 19.4%
	3			MA -3.4/-3.7
	4		--	
-5	5		GRAY, SILTY SAND (SM), WITH PLASTIC FINES AND POCKETS OF FAT CLAY (CH), AND A TRACE OF SHELL FRAGMENTS.	MA -4.6/-4.9
	6		--	
	7			B -7.0/-7.4 WET DEN. = 92.9, DRY DEN. = 58.2, M. C. = 59.7
	8			
	9			
-10	10		GRAY, FAT CLAY (CH), WITH A TRACE OF SAND SIZES AND ORGANICS.	
	11			
	12			C -11.8/-12.2 WET DEN. = 94.5, DRY DEN. = 60.9, M. C. = 55.2
	13			
	14		--	
-15				

Date: 04/19/94 **LABORATORY LOG AND SAMPLE DATUM** Sheet No. 1 of 1

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612

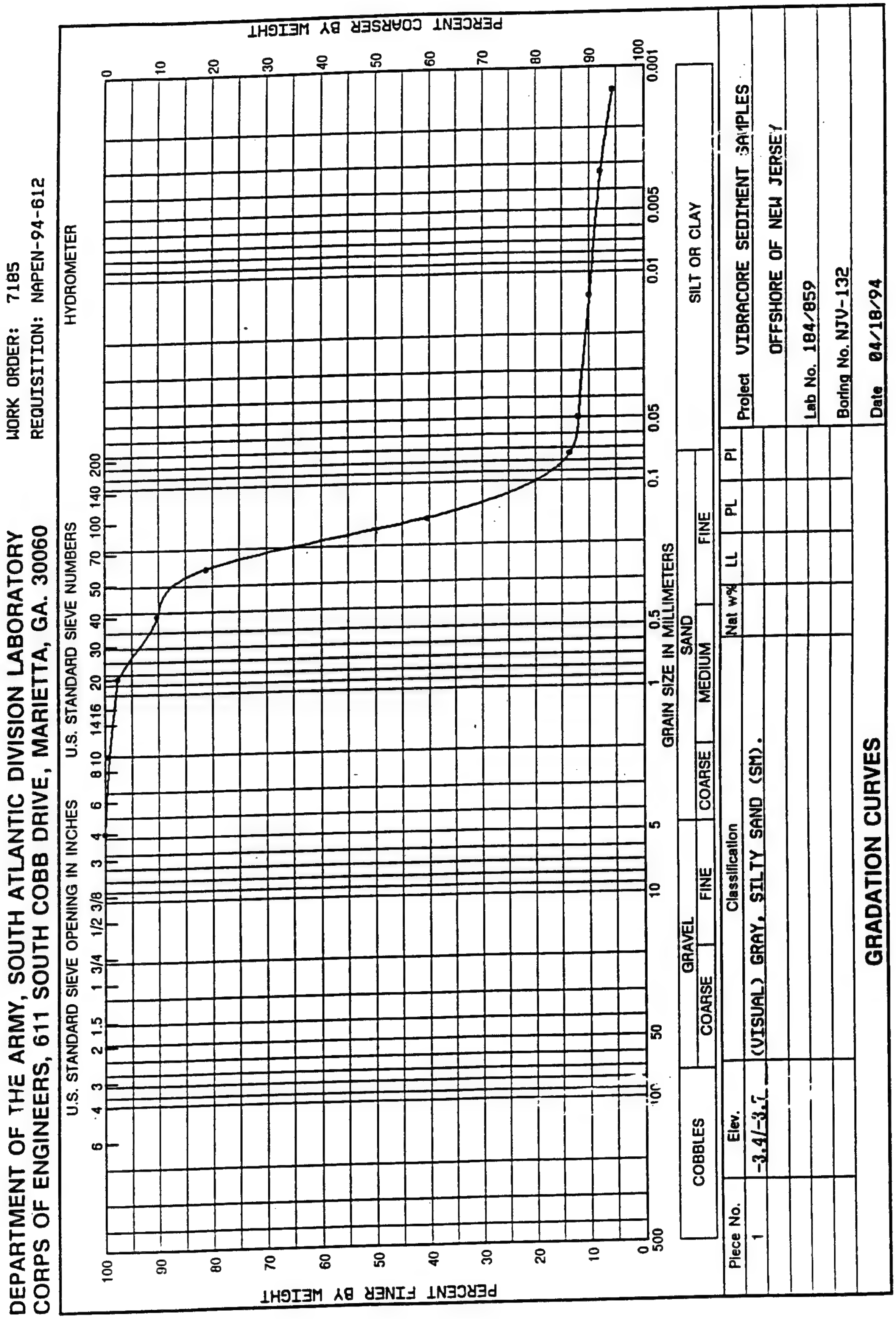


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-2.1 / -2.5'	(VISUAL) LT. GRAY, POORLY GRADED SILTY	19.4			
		SAND (SP-SM), WITH A TRACE OF SHELL FRAG				
		SP. GRAVITY = 2.68				
		WET DENSITY = 127.8 PCF.				
		DRY DENSITY = 107.0 PCF.				

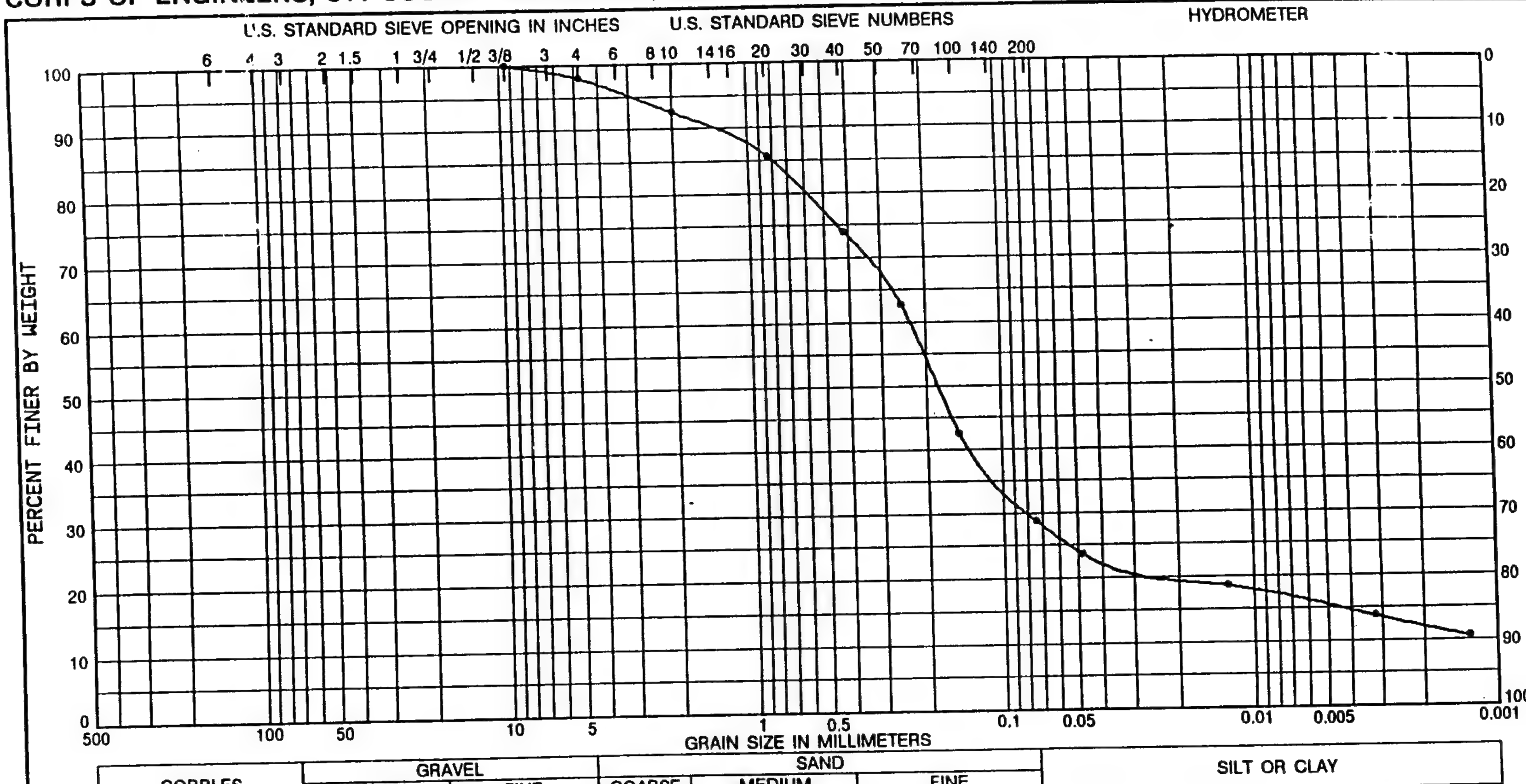
Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/859A
Boring No. NJV-132
Date 04/07/94

GRADATION CURVES


DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060
WORK ORDER: 7185
REQUISITION: NAPEN-94-612
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Piece No.
Elev.
Classification
Nat w%
LL
PL
PI
1
-3.4/-3.7
(VISUAL) GRAY, SILTY SAND (SM).
Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/859
Boring No. NJV-132
Date 04/18/94
GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



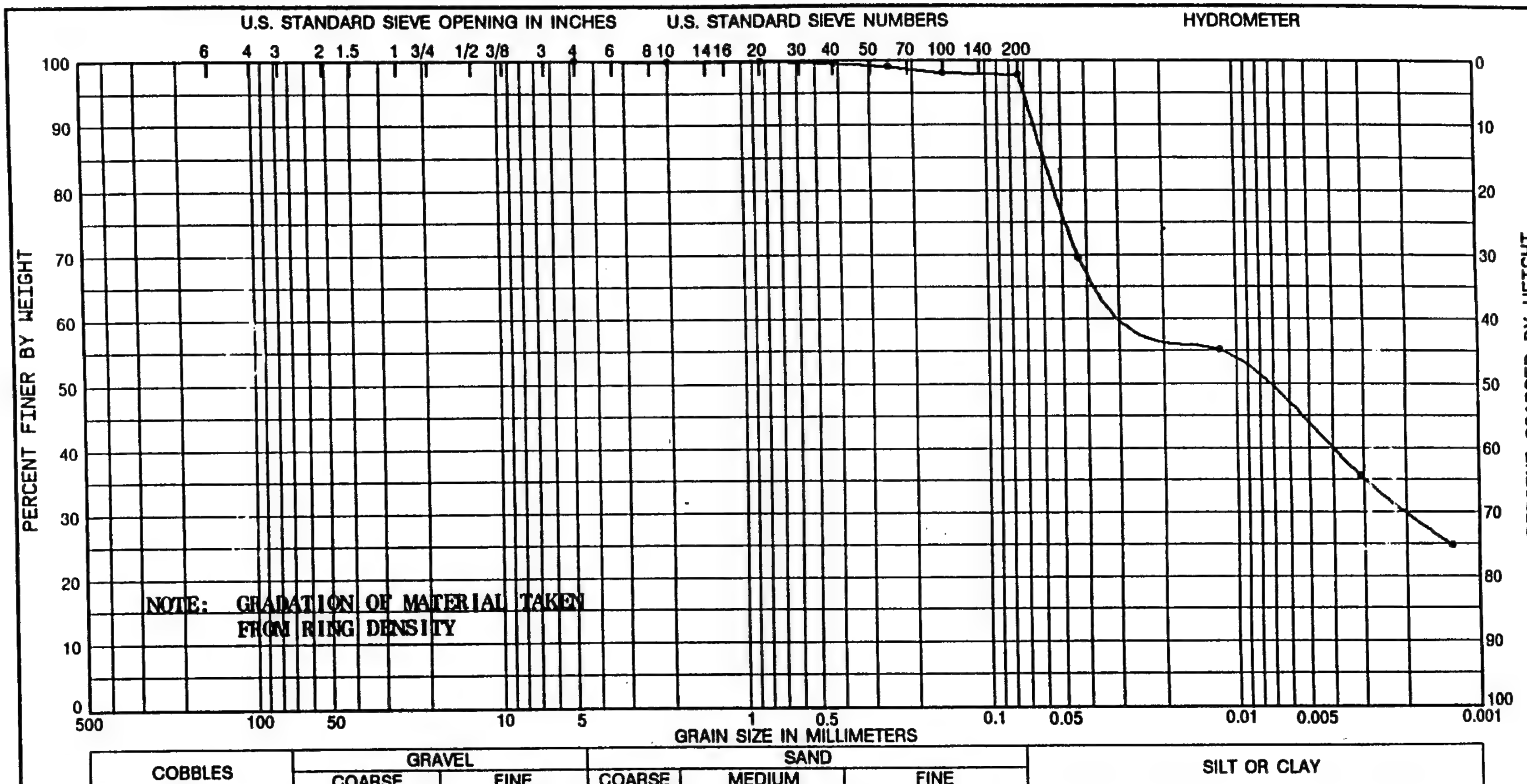
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 4.6 / - 4.9'	(VISUAL) GRAY, SILTY SAND (SM), WITH PLASTIC FINES AND A TRACE OF GRAVEL SIZES, SHELL FRAGMENTS AND MICA.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/859
Boring No. NJV-132
Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-7.0 / -7.4'	(VISUAL) GRAY, FAT CLAY (CH), WITH A	59.7			
		TRACE OF SAND SIZES AND ORGANICS.				
		SP. GRAVITY = 2.70				
		WET DENSITY = 92.9 PCF.				
		DRY DENSITY = 58.2 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/859B

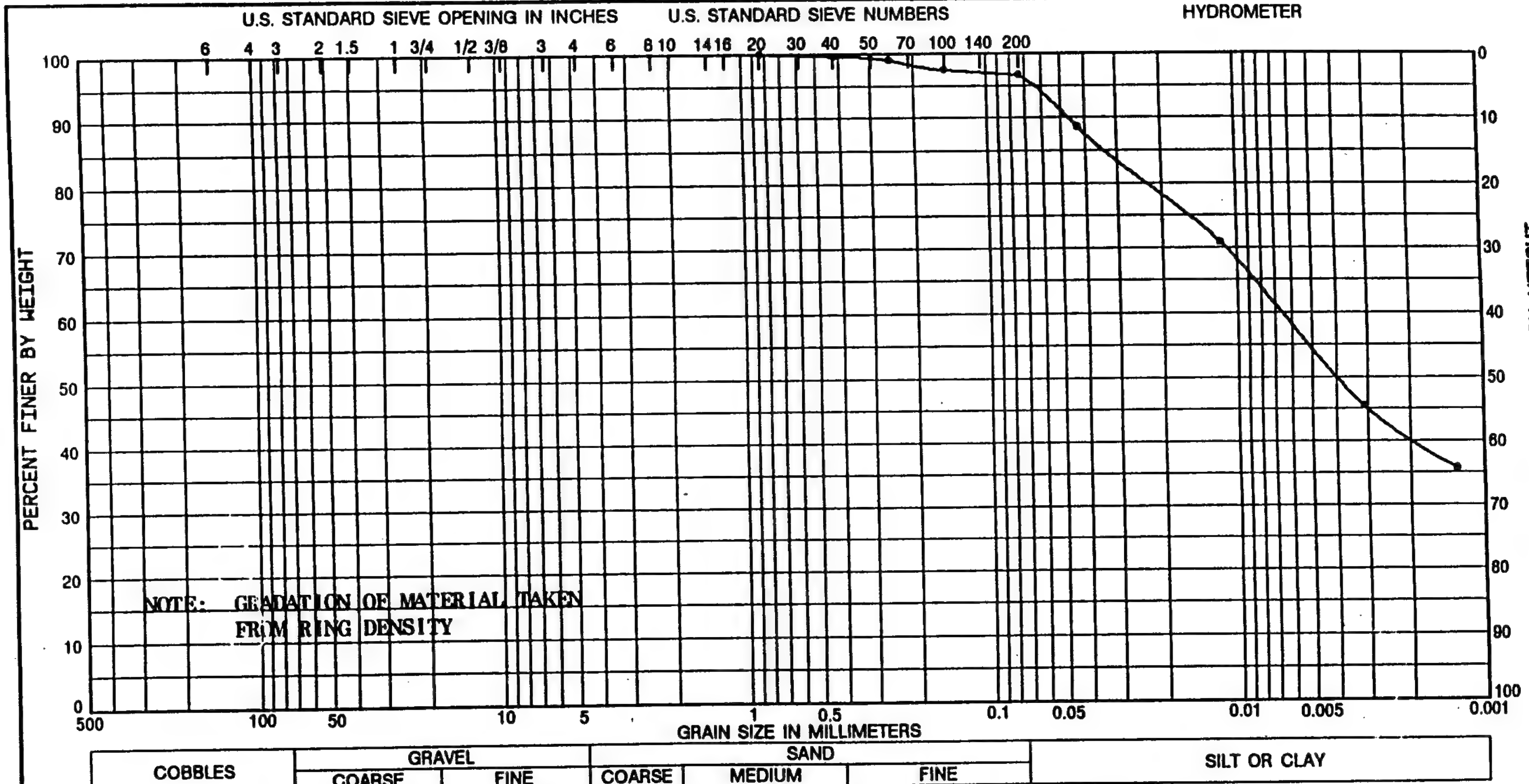
Boring No. NJV-132

Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-11.8 / -12.2'	(VISUAL) GRAY, FAT CLAY (CH), WITH A	55.2			
		TRACE OF SAND SIZES AND ORGANICS.				
		SP. GRAVITY = 2.69				
		WET DENSITY = 94.5 PCF.				
		DRY DENSITY = 60.9 PCF.				

Project VIBRACORE SEDIMENT SAMPLES OFFSHORE OF NEW JERSEY

Lab No. 184/859C

Boring No. NJV-132

Date 04/20/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

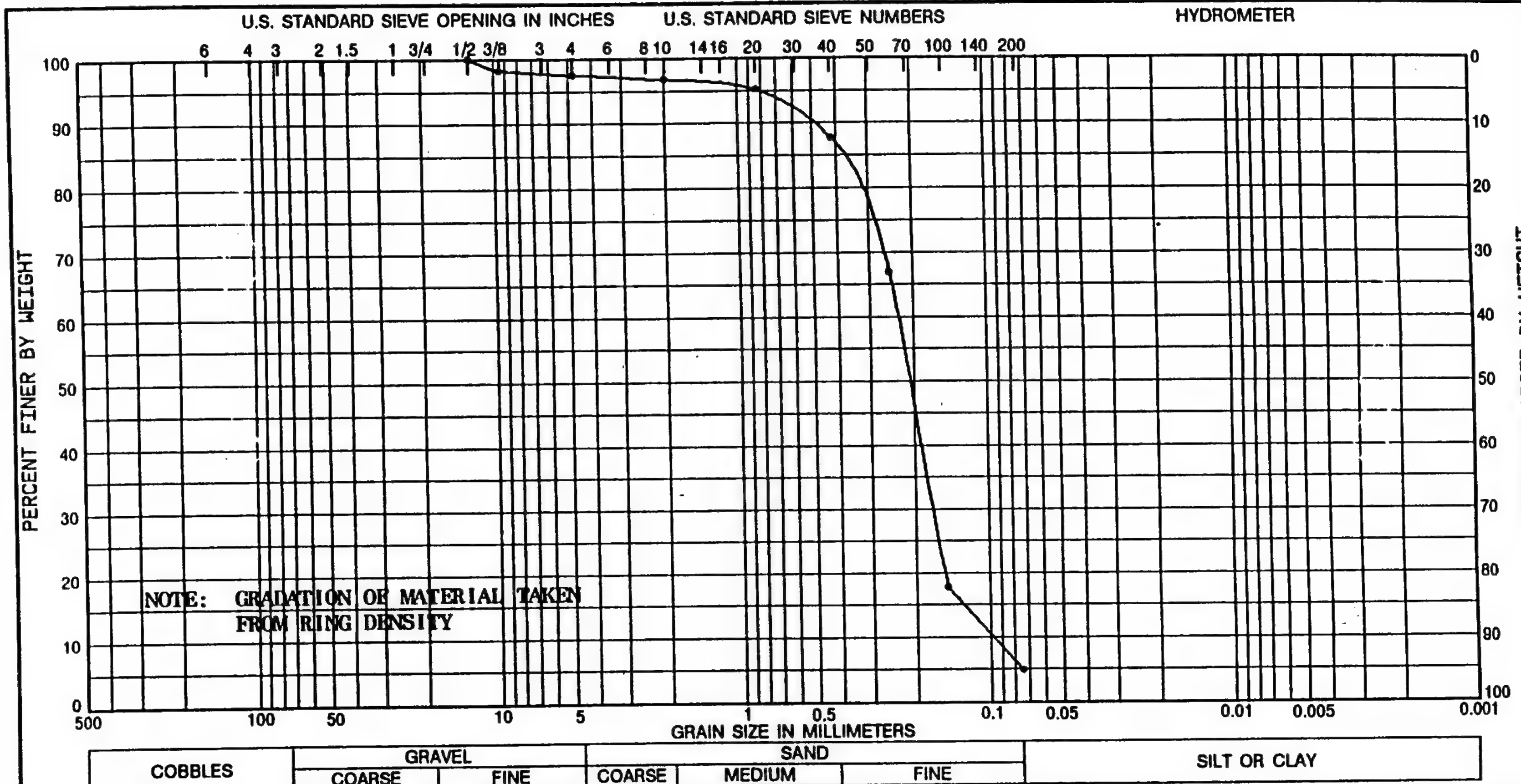
Project: *VIBRACORE SEDIMENT SAMPLES*	Boring No. *NJV-133*
Location: *OFFSHORE OF NEW JERSEY*	Lab No. *184/860*
Boring Depth (ft): *16.00* — Elevation: ———	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*	Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0				
	1			
	2		TAN, POORLY GRADED SAND (SP), WITH A TRACE OF GRAVEL SIZES AND SHELL FRAGMENTS.	
	3			A -3.0/-3.4 WET DEN. = 130.1, DRY DEN. = 110.2 M. C. = 18.0%
	4			
-5	5		LAYERS AND POCKETS OF GRAY, FAT CLAY (CH), AND POORLY GRADED SAND (SP).	MA -4.8/-5.1
	6			
	7		TAN AND GRAY, SILTY SAND (SM), WITH POCKETS OF GRAY FAT CLAY (CH) AND A TRACE OF MICA.	
	8			B -7.7/-8.1 WET DEN. = 131.6, DRY DEN. = 113.9, M. C. = 15.5%
	9		GRAY CLAYEY SAND (SC).	MA -8.7/-9.0
-10	10			SA -9.8/-10.2
	11		TAN AND GRAY, POORLY GRADED SAND (SP), WITH OCCASIONAL POCKETS OF FAT CLAY (CH), AND A TRACE OF GRAVEL SIZES.	
	12			MA -11.6/-11.9
	13		TAN, POORLY GRADED SILTY SAND (SP-SM), WITH A LITTLE GRAVEL SIZES.	C -12.5/-12.9 WET DEN. = 134.9, DRY DEN = 118.2, M. C. = 14.1% SA -13.3/-13.7
	14			
-15	15		TAN AND GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.	SA -15.0/-15.2
	16			
	17			

Date: *04/19/94* — **LABORATORY LOG AND SAMPLE DATUM** — Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



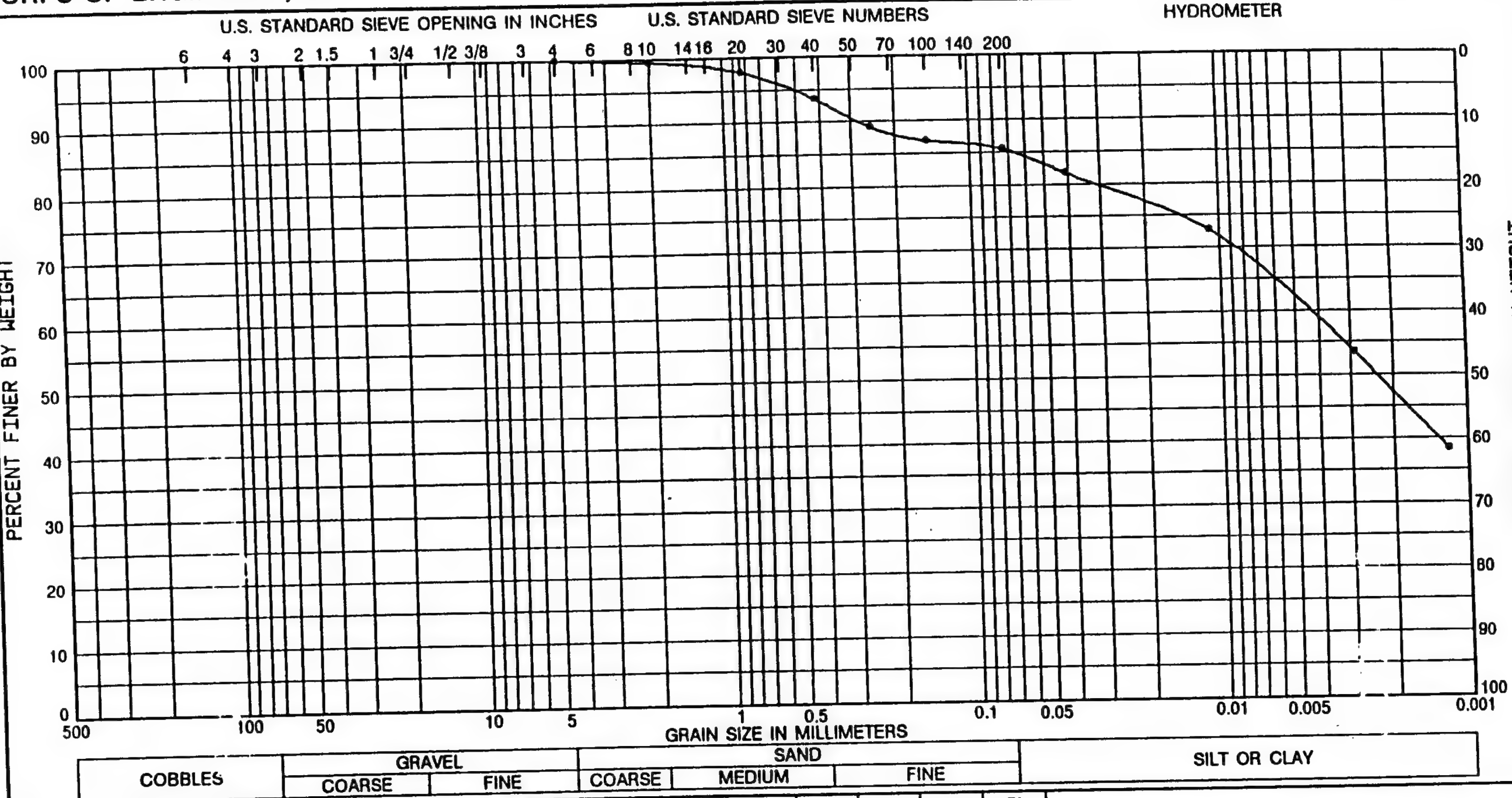
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-3.0 / -3.4'	(VISUAL) TAN, POORLY GRADED SAND (SP),	18.0			
		WITH A TRACE OF GRAVEL SIZES AND SHELL FRAG.				
		SP. GRAVITY = 2.67				
		WET DENSITY = 130.1 PCF.				
		DRY DENSITY = 110.2 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/860A
Boring No. NJV-133
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	- 4.8 / - 5.1'	(VISUAL) GRAY, FAT CLAY (CH), WITH A LITTLE SAND SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/860

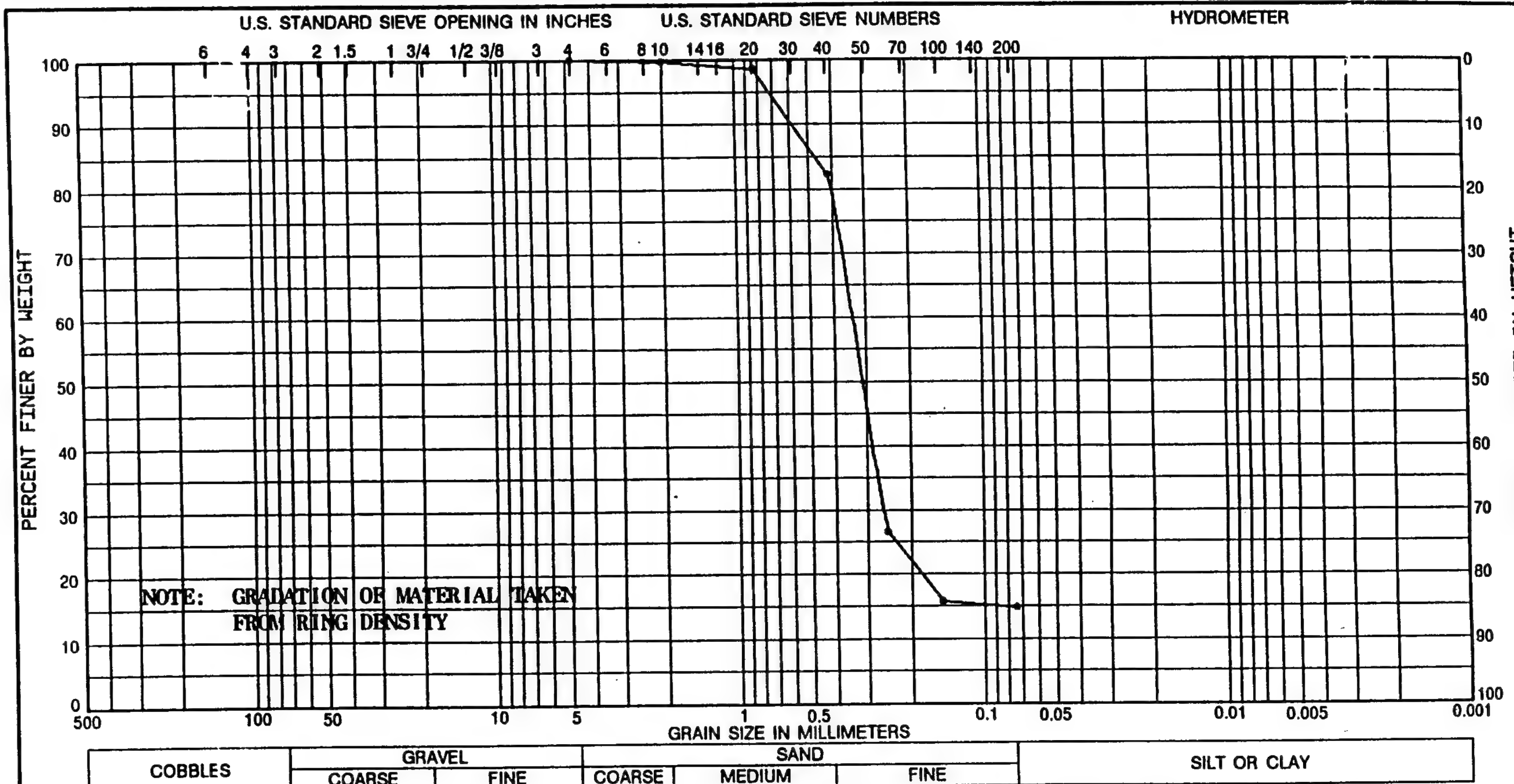
Boring No. NJV-133

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	-7.7 / -8.1'	(VISUAL) TAN AND GRAY, SILTY SAND (SM),	15.5			
		WITH A TRACE OF MICA.				
		SP. GRAVITY = 2.66				
		WET DENSITY = 131.6 PCF.				
		DRY DENSITY = 113.9 PCF.				

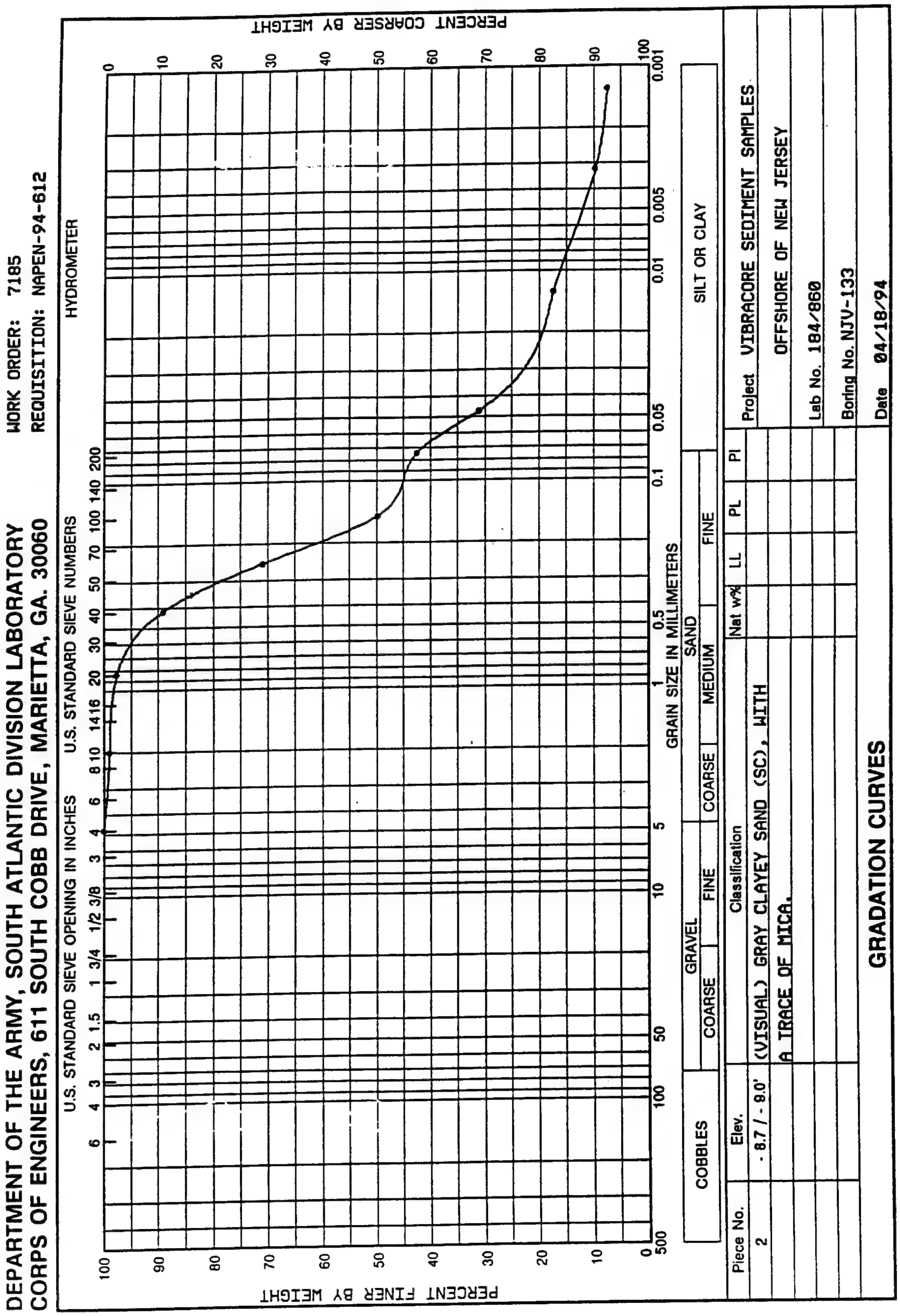
Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/860B

Boring No. NJV-133

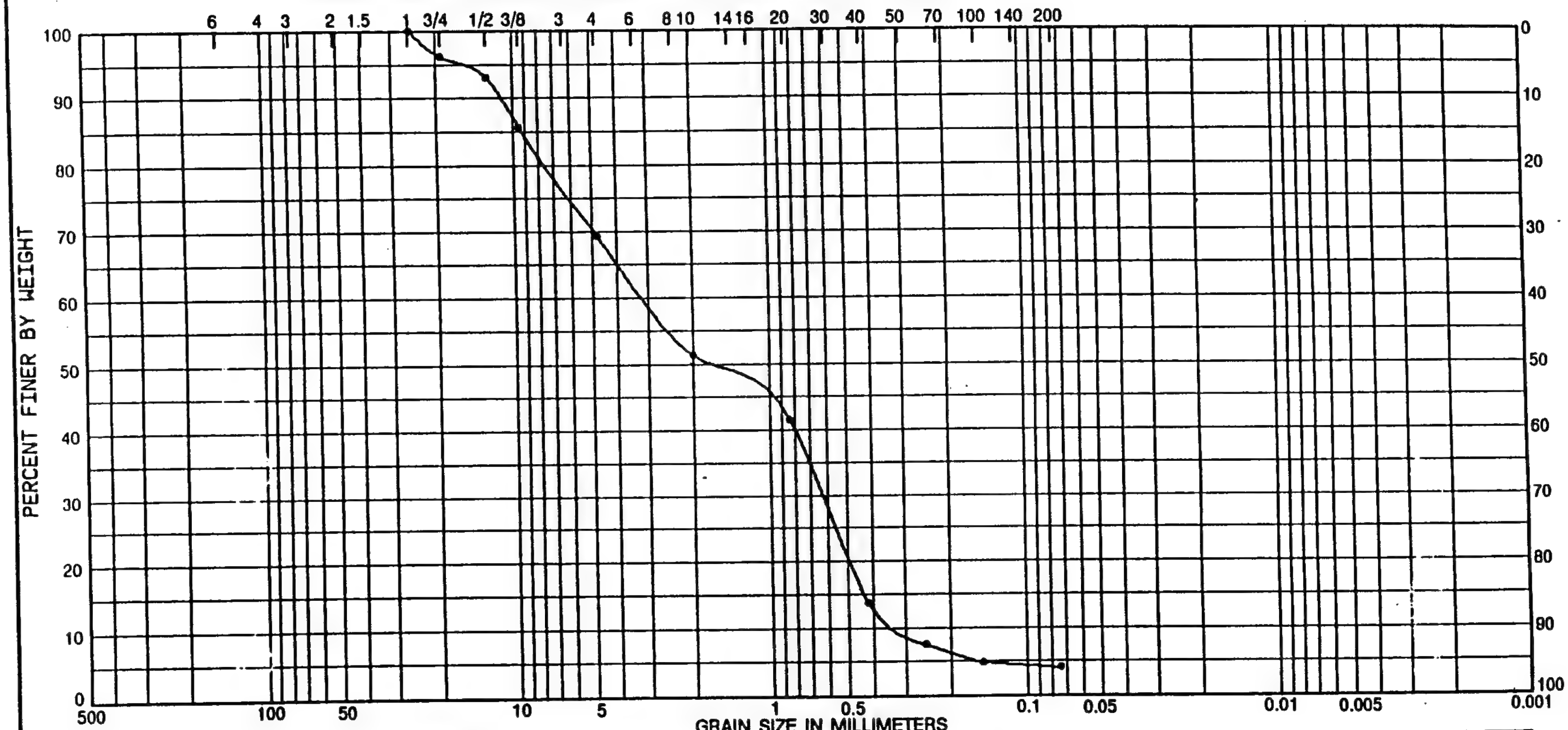
Date 04/07/94

GRADATION CURVES


DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060
WORK ORDER: 7185
REQUISITION: NAPEN-94-612
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Piece No.
2
Elev.
- 8.7 / - 9.0'
Classification
(VISUAL) GRAY CLAYEY SAND (SC), WITH
A TRACE OF MICA.
Nat w%
LL
PL
PI
Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/860
Boring No. NJV-133
Date 04/18/94
GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
2	- 9.8 / -10.2'	(VISUAL) TAN AND GRAY, POORLY GRADED SAND (SP), WITH SOME GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/860

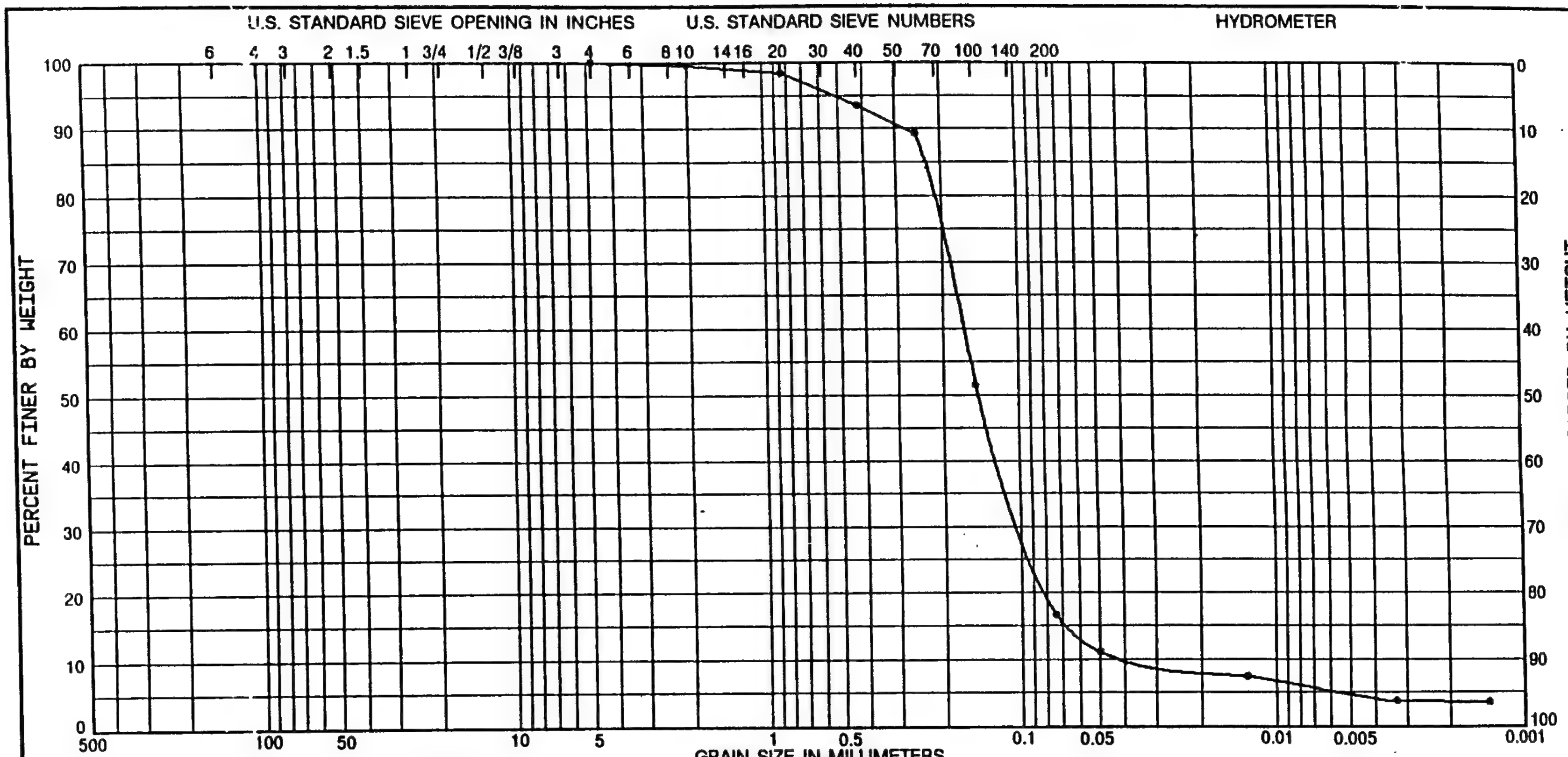
Boring No. NJV-133

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	- 11.6 / -11.9'	(VISUAL) TAN AND GRAY, SILTY SAND (SM),				
		WITH PLASTIC FINES AND A TRACE OF MICA.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY

Lab No. 184/860

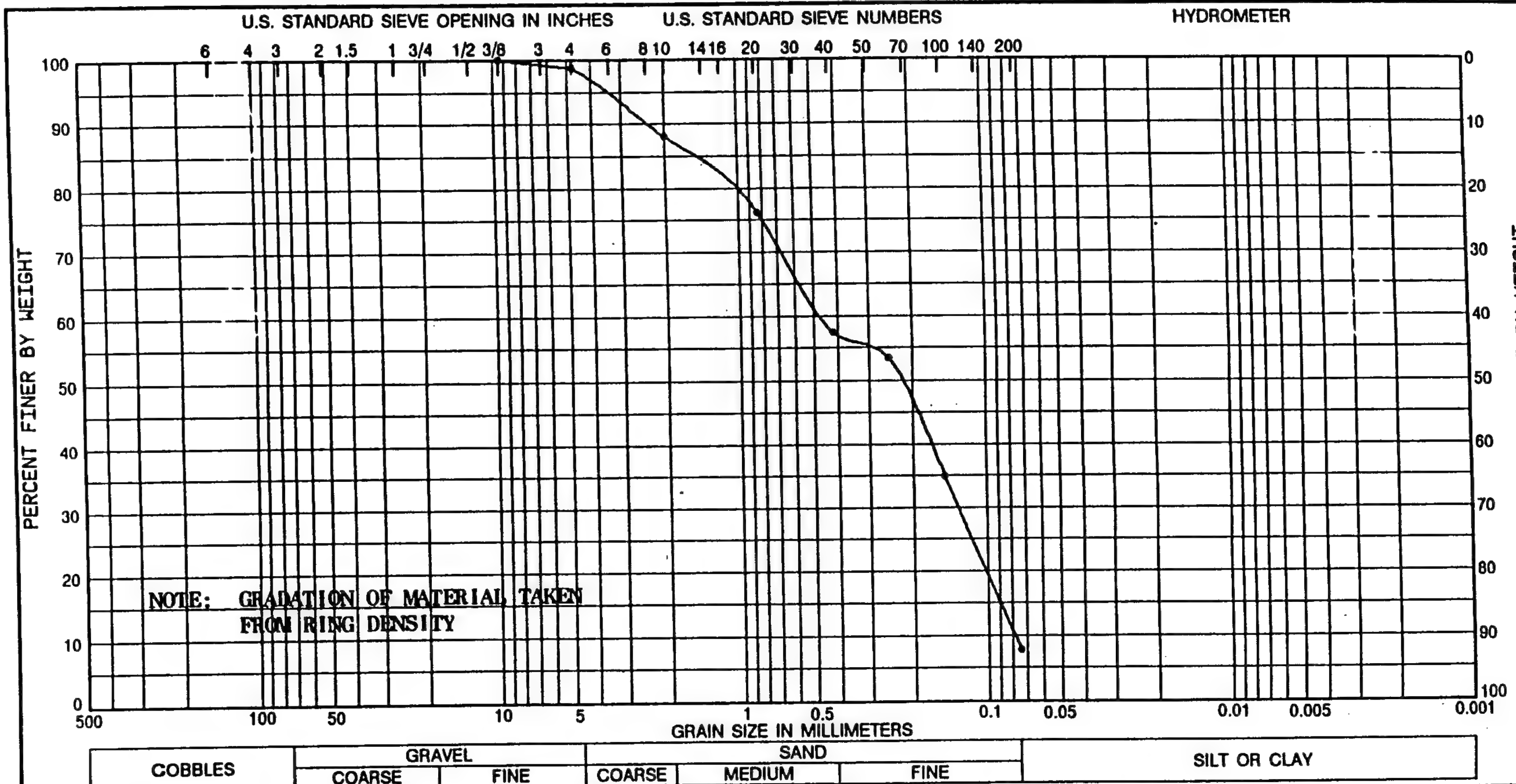
Boring No. NJV-133

Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612

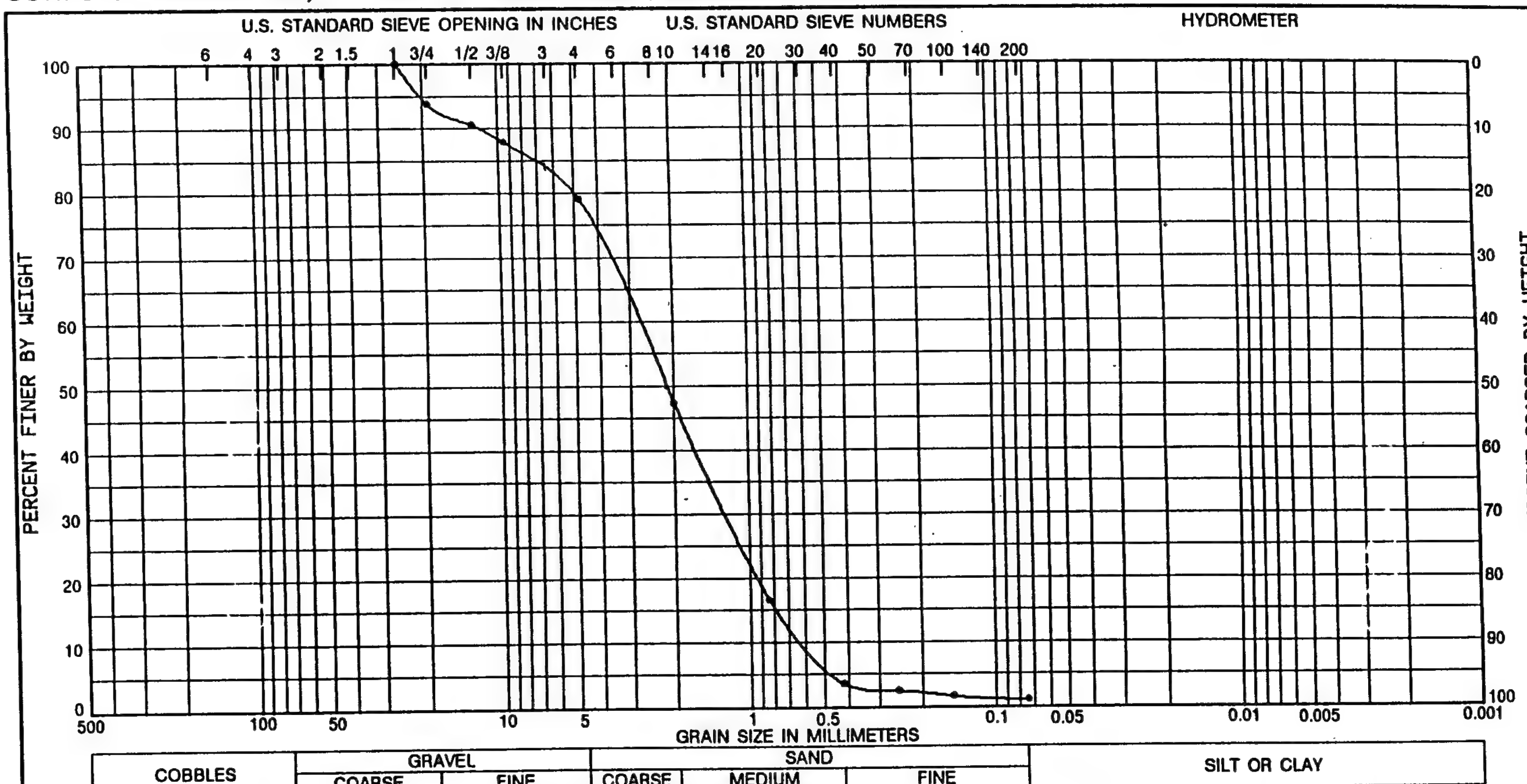


Piece No.	Elev.	Classification	Nat w%	LL	PL	PI	
3	-12.5 / -12.9'	(VISUAL) TAN AND GRAY, POORLY GRADED	14.1				Project VIBRACORE SEDIMENT SAMPLES
		SILTY SAND (SP-SM), WITH A TRACE OF					OFFSHORE OF NEW JERSEY
		GRAVEL SIZES AND MICA. SP. G. = 2.72					Lab No. 184/860C
		WET DENSITY = 134.9 PCF.					Boring No. NJV-133
		DRY DENSITY = 118.2 PCF.					Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



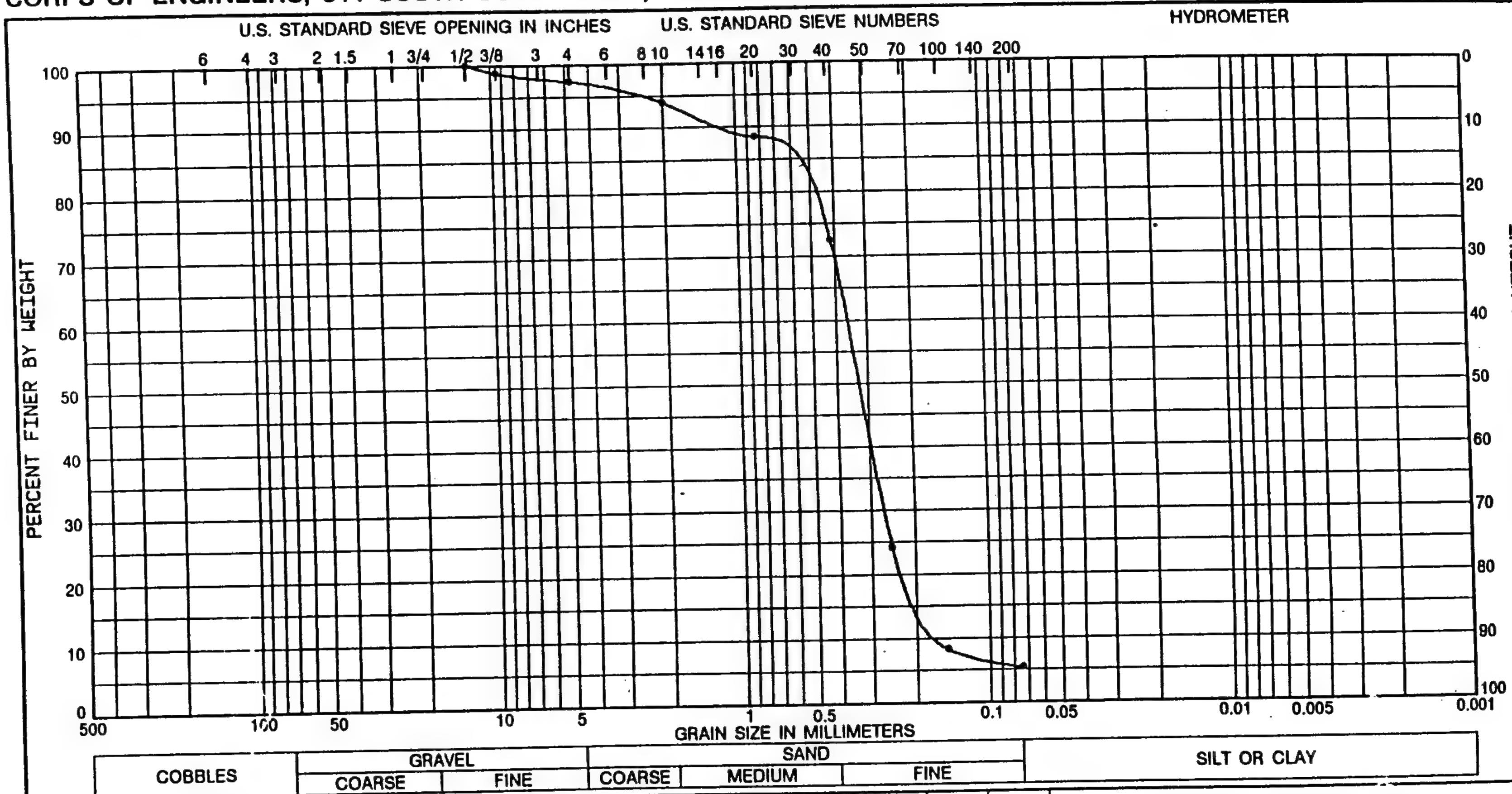
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	- 13.3 / -13.7'	(VISUAL) TAN, POORLY GRADED SAND (SP), WITH SOME GRAVEL SIZES AND A TRACE OF MICA.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/860
Boring No. NJV-133
Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	- 15.0 / -15.2'	(VISUAL) TAN AND GRAY, POORLY GRADED SILTY SAND (SP-SM), WITH A TRACE OF GRAVEL SIZES.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/880
Boring No. NJV-133
Date 04/18/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

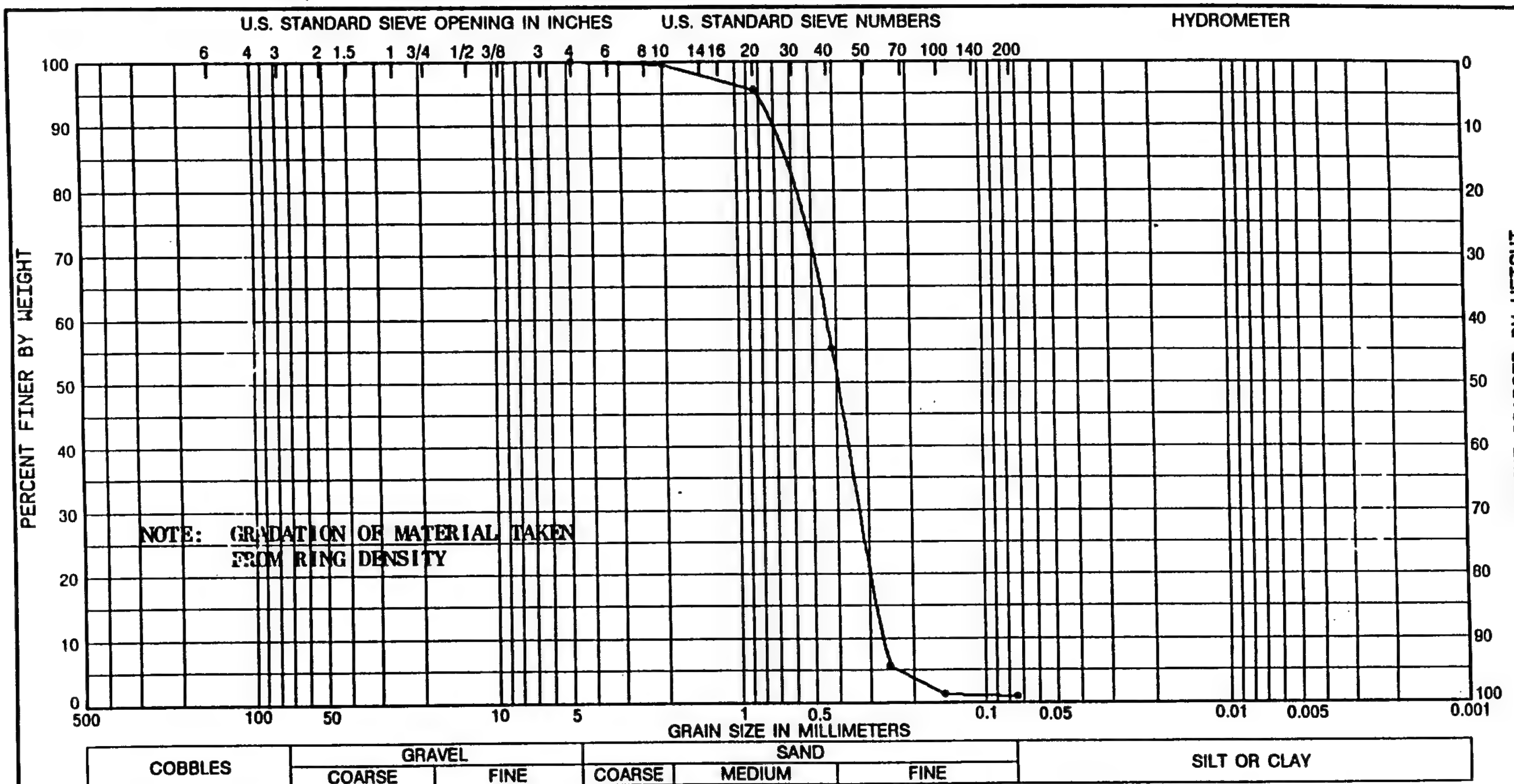
Project: *VIBRACORE SEDIMENT SAMPLES*	Boring No. *NJV-134*
Location: *OFFSHORE OF NEW JERSEY*	Lab No. *184/861*
Boring Depth (ft): *17.30* — Elevation: ——	Work order: *7185*
Datum/Notes: *See grain size data on enclosed gradation curves.*	Requisition: *NAPEN-94-612*

Elev. (feet)	Depth (feet)	Legend	Material Description	Comments
0	0			
	1			
	2			
	3			A -2.9/-3.3 WET DEN. = 130.9, DRY DEN. = 113.8, M. C. = 15.0%
	4			
-5	5			
	6			
	7		TAN, POORLY GRADED SAND (SP), WITH POCKETS OF SHELL FRAGMENTS.	
	8			B -7.9/-8.3 WET DEN. = 124.8, DRY DEN. = 107.9, M. C. = 15.7%
	9			
-10	10			
	11			C -11.4/-11.8 WET DEN. = 123.0, DRT DEN. = 108.9, M. C. = 12.9%
	12			
	13		--	
	14			MA -14.6/-15.0
-15	15		GRAY, FAT CLAY (CH), WITH OCCASIONAL LENSES AND POCKETS OF SILTY SAND (SM).	D -15.3/-15.8 WET DEN. = 116.5, DRY DEN. = 90.0, M. C. = 29.4%
	16		--	SA -16.4/-16.7
	17		GRAY, POORLY GRADED SAND (SP).	
			--	

Date: *04/20/94* — LABORATORY LOG AND SAMPLE DATUM — Sheet No. *1* of *1*

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



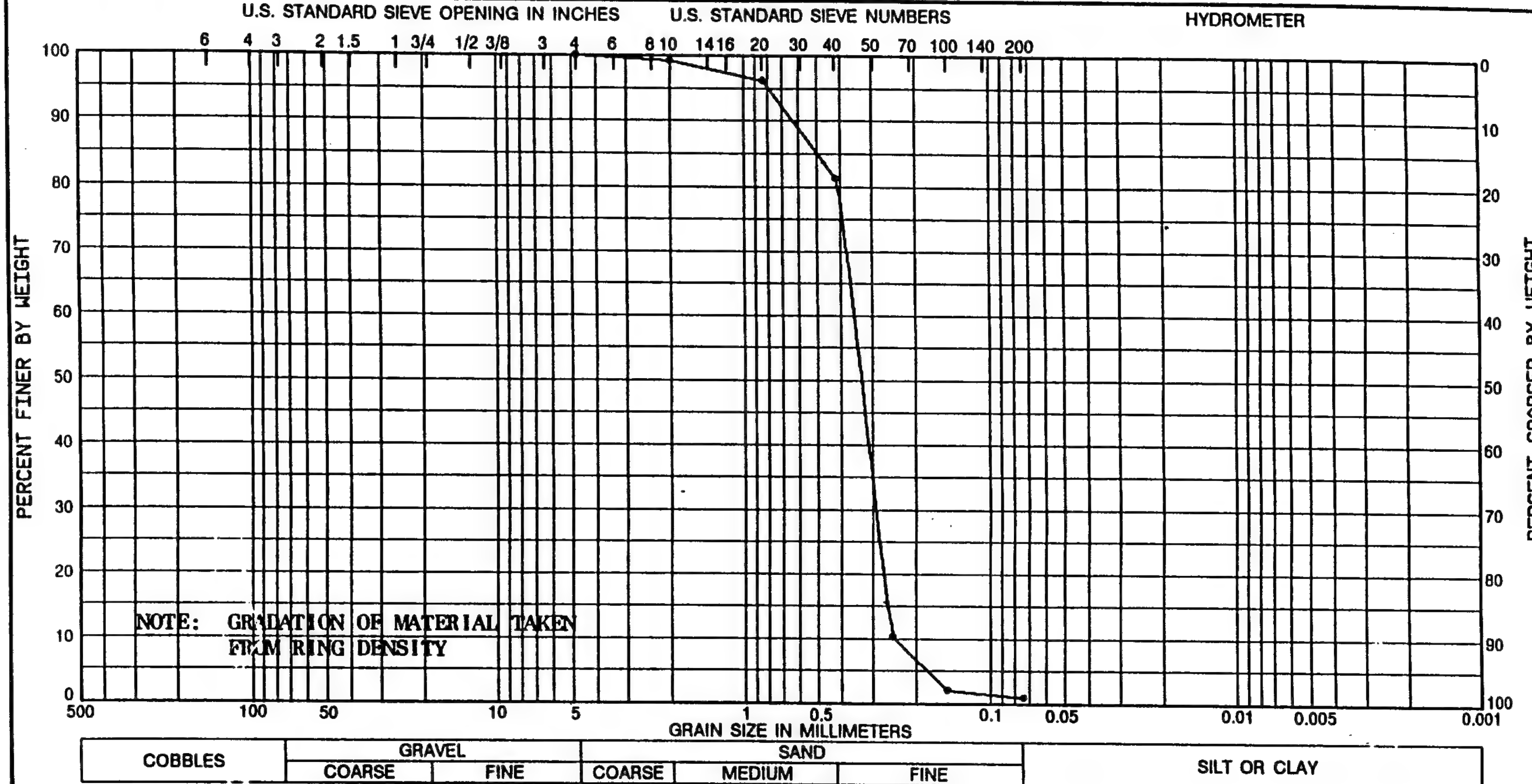
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
1	-2.9 / -3.3'	(VISUAL) TAN, POORLY GRADED SAND (SP).	15.0			
		SP. GRAVITY = 2.65				
		WET DENSITY = 130.9 PCF.				
		DRY DENSITY = 113.8 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/861A
Boring No. NJV-134
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-812



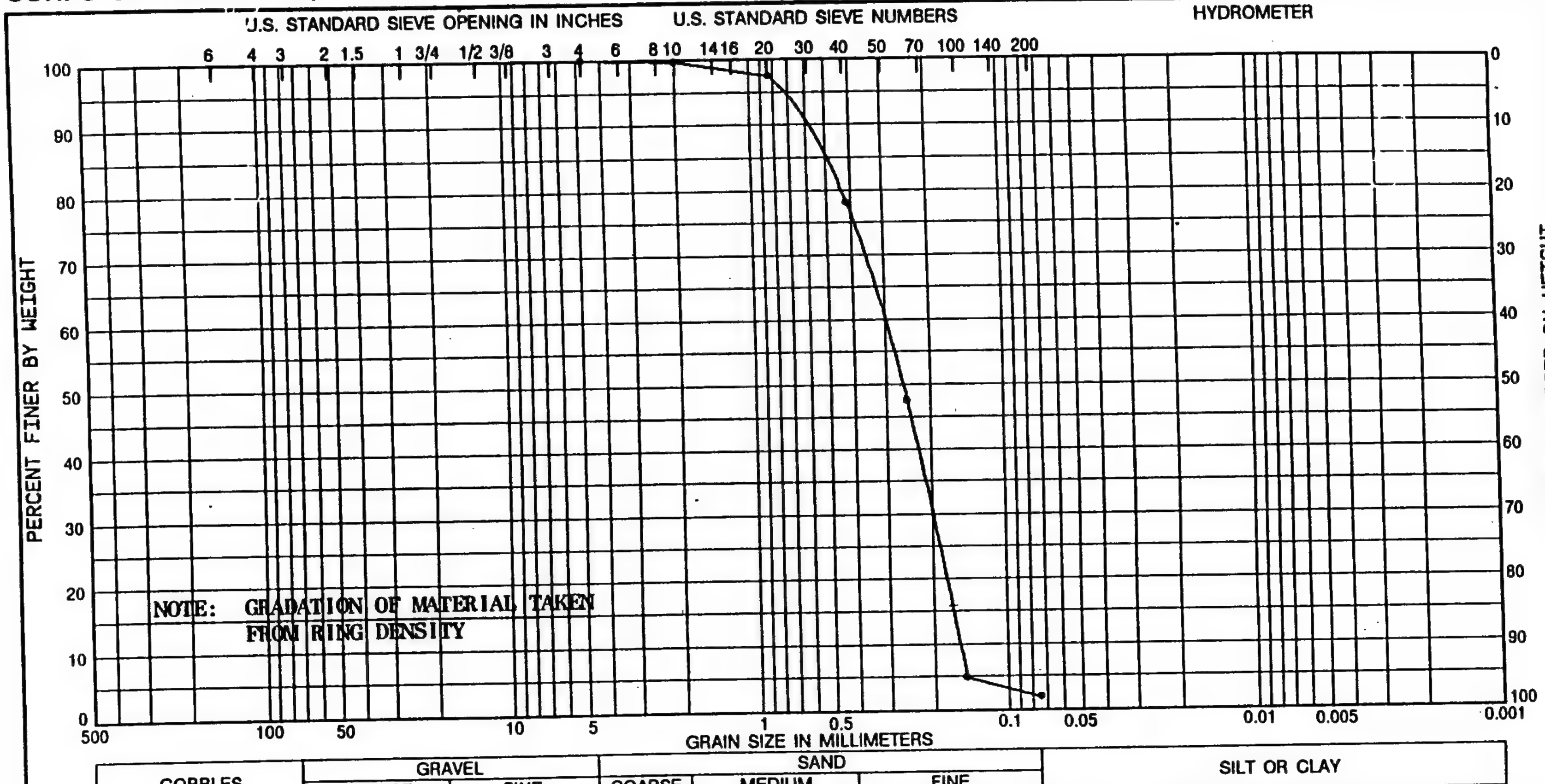
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
3	-7.9 / -8.3'	(VISUAL) TAN, POORLY GRADED SAND (SP),	15.7			
		WITH A TRACE OF SHELL FRAGMENTS.				
		SP. GRAVITY = 2.65				
		WET DENSITY = 124.8 PCF.				
		DRY DENSITY = 107.9 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/861B
Boring No. NJV-134
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



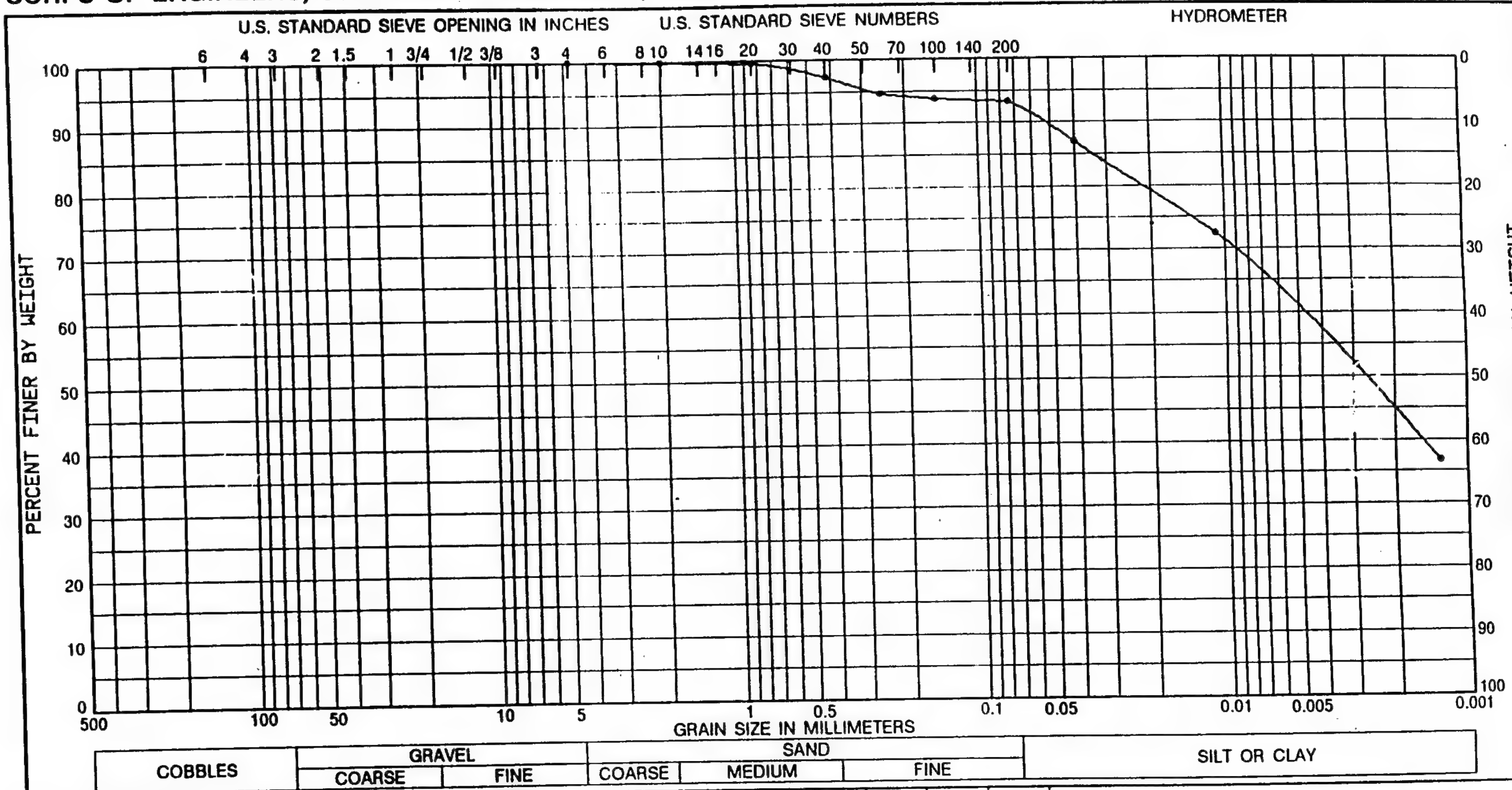
Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
4	-11.4 / -11.8'	(VISUAL) TAN, POORLY GRADED SAND (SP).	12.9			
		SP. GRAVITY = 2.66				
		WET DENSITY = 123.0 PCF.				
		DRY DENSITY = 108.9 PCF.				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/861C
Boring No. NJV-134
Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
5	- 14.7 / - 15.0	(VISUAL) GRAY, FAT CLAY (CH), WITH A TRACE OF SAND AND MICA.				

Project VIBRACORE SEDIMENT SAMPLES OFFSHORE OF NEW JERSEY

Lab No. 184/861

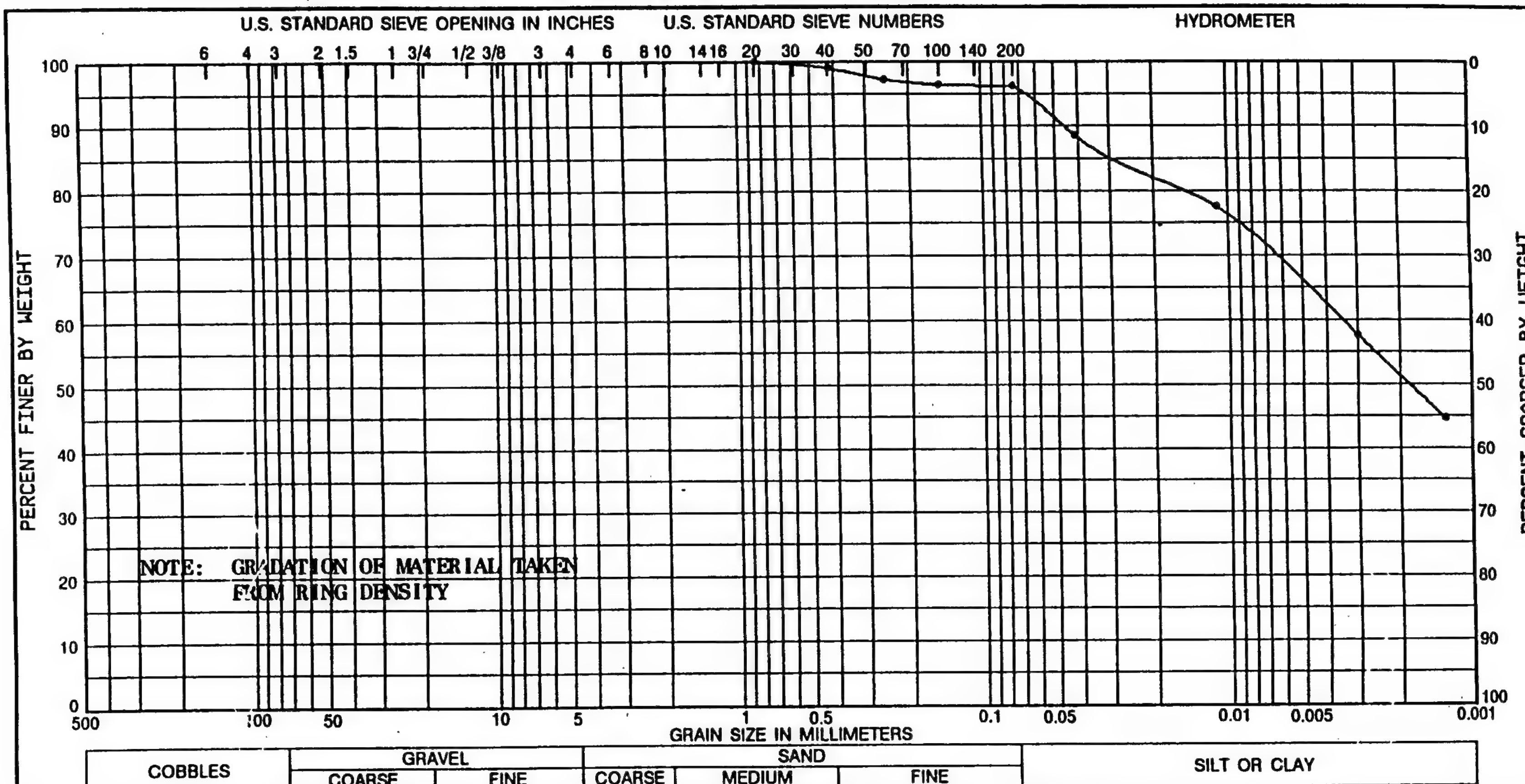
Boring No. NJV-134

Date 04/20/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612

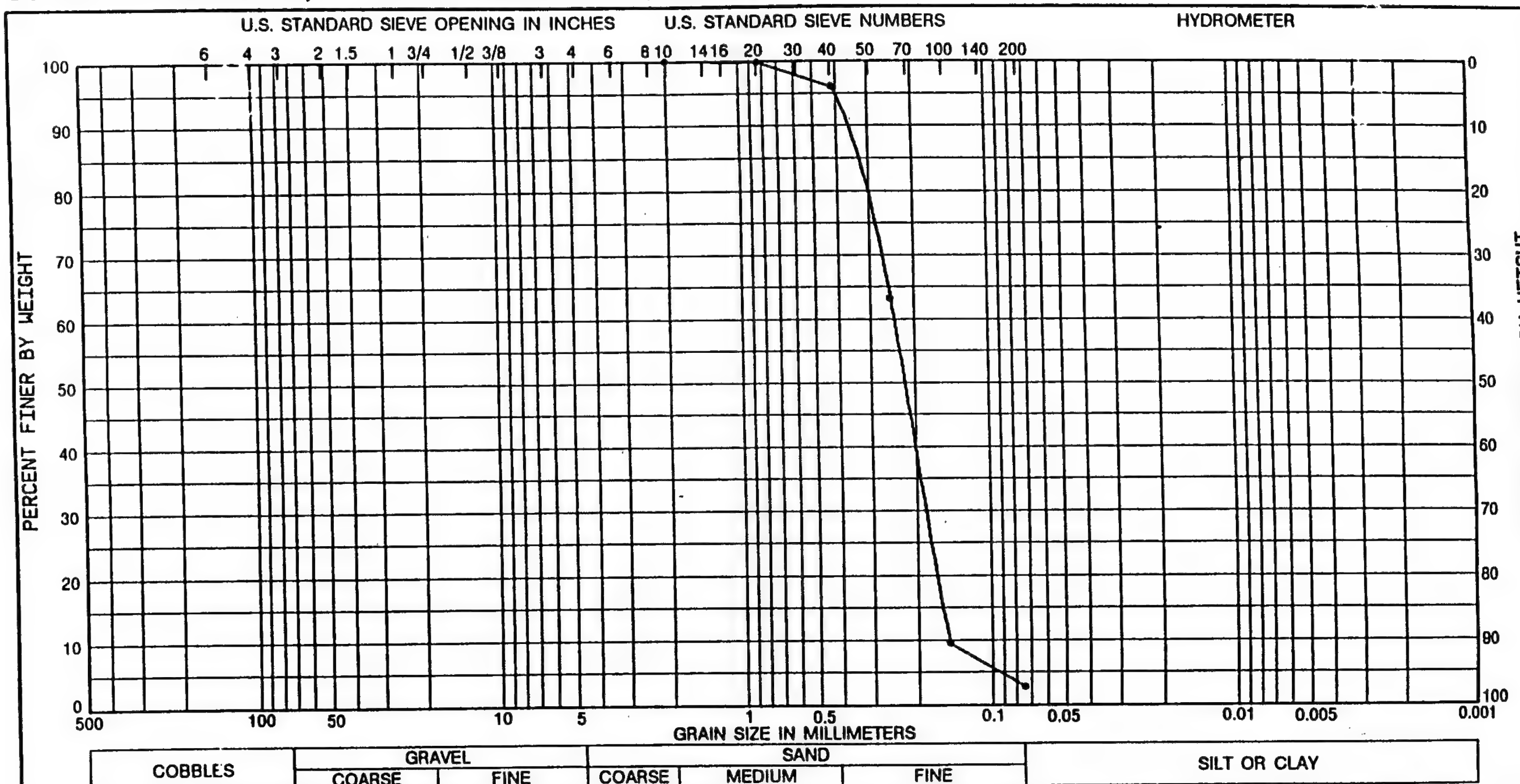


Piece No.	Elev.	Classification	Nat w%	LL	PL	PI	
5	-15.3 / -15.8'	(VISUAL) GRAY, FAT CLAY (CH), WITH A	29.4				Project VIBRACORE SEDIMENT SAMPLES
		TRACE OF SAND.					OFFSHORE OF NEW JERSEY
		SP. GRAVITY = 2.68					Lab No. 184/861D
		WET DENSITY = 116.5 PCF.					Boring No. NJV-134
		DRY DENSITY = 90.0 PCF.					Date 04/07/94

GRADATION CURVES

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER: 7185
REQUISITION: NAPEN-94-612



Piece No.	Elev.	Classification	Nat w%	LL	PL	PI
5	- 16.4 / -13.7'	(VISUAL) GRAY, POORLY GRADED SAND (SP).				

Project VIBRACORE SEDIMENT SAMPLES
OFFSHORE OF NEW JERSEY
Lab No. 184/861
Boring No. NJV-134
Date 04/18/94

GRADATION CURVES

Appendix B New Jersey Coast Acoustic Core Density Plots

Density versus depth plots for selected acoustic data files are presented herein. These plots are referenced on the sediment profile plots (Plates 1-10) with the prefix AC followed by the line number and individual file number. These acoustic core density plots are presented in ascending order along each survey profile. Table B1 lists each acoustic core plot, identifying the survey line and data line number and plate reference.

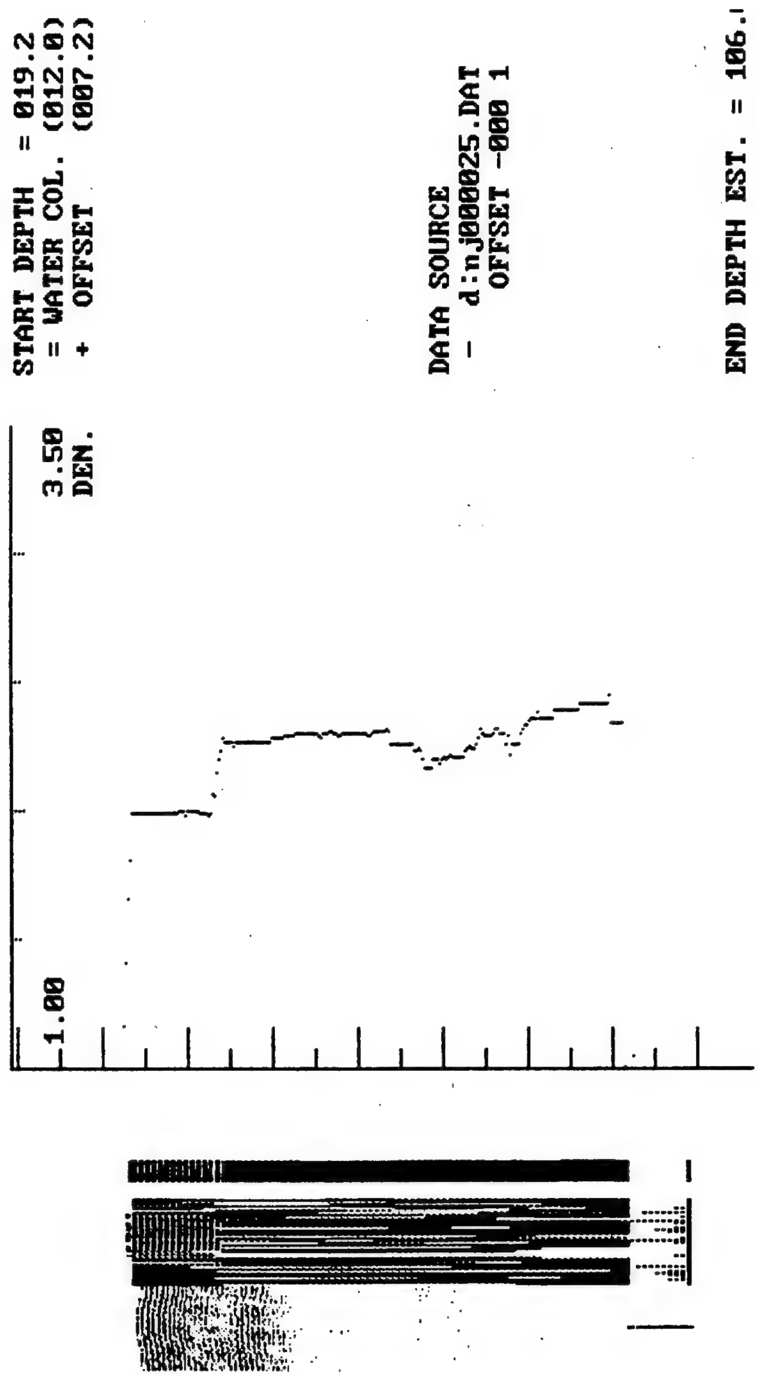
A typical density plot (refer to any enclosed plot) consists of three normally color-coded vertical profile columns as shown on the left of each figure. The plots are presented in black and white to conserve printing costs, negating the benefits of color-coding the results and therefore making the amplitude and impedance versus depth portions of the plots difficult to distinguish. The first column is the acoustic amplitude segment for the data subfile, consisting of 40 consecutive soundings. The second column is coded impedance segment calculations while the third column depicts an average of the previous impedance calculations. The final calculation, density as a function of depth, is then plotted. It is important to note that the signal-to-noise (S/N) ratio degrades with depth causing erroneous impedance calculations. This is indicated on the plot by a black color code on the impedance segment that is probably indistinguishable on the black-and white copies provided here. For the plots presented, the bottom 5-10 ft of the density profile is basically unusable information due to the S/N.

Table B1
New Jersey Coast Acoustic Cores

Acoustic Core Name	Plate in Main Text
AC-00-25/1	1
AC-00-16/0	1
AC-00-4/5	1
AC-01-7/1	2
AC-01-37/0	2
AC-01-39/1	2
AC-01-57/0	2
AC-01-60/2	2
AC-01-89/4	2
AC-01-91/2	2
AC-02-54/1	3
AC-02-33/3	3
AC-02-26/5	3
AC-02-18/4	3
AC-02-17/0	3
AC-02-2/1	3
AC-03-02/0	4
AC-03-23/4	4
AC-03-57/5	4
AC-03-66/4	4
AC-04-66/0	5
AC-04-55/0	5
AC-04-44/3	5
AC-04-32/3	5
AC-04-19/5	5
AC-04-5/0	5
AC-05-4/5	6
AC-05-7/5	6
AC-05-27/4	6
AC-05-65/3	6
AC-06-41/5	7

(Continued)

Table B1 (Concluded)	
Acoustic Core Name	**Plate in Main Text**
AC-06-35/0	7
AC-06-29/3	7
AC-06-20/0	7
AC-06-7/0	7
AC-06-3/1	7
AC-06-1/0	7
AC-07-10/0	8
AC-07-20/0	8
AC-07-66/5	8
AC-07-67/3	8
AC-07-68/4	8
AC-08-5/2	9
AC-08-28/4	9
AC-08-35/1	9
AC-08-41/1	9
AC-08-46/0	9


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
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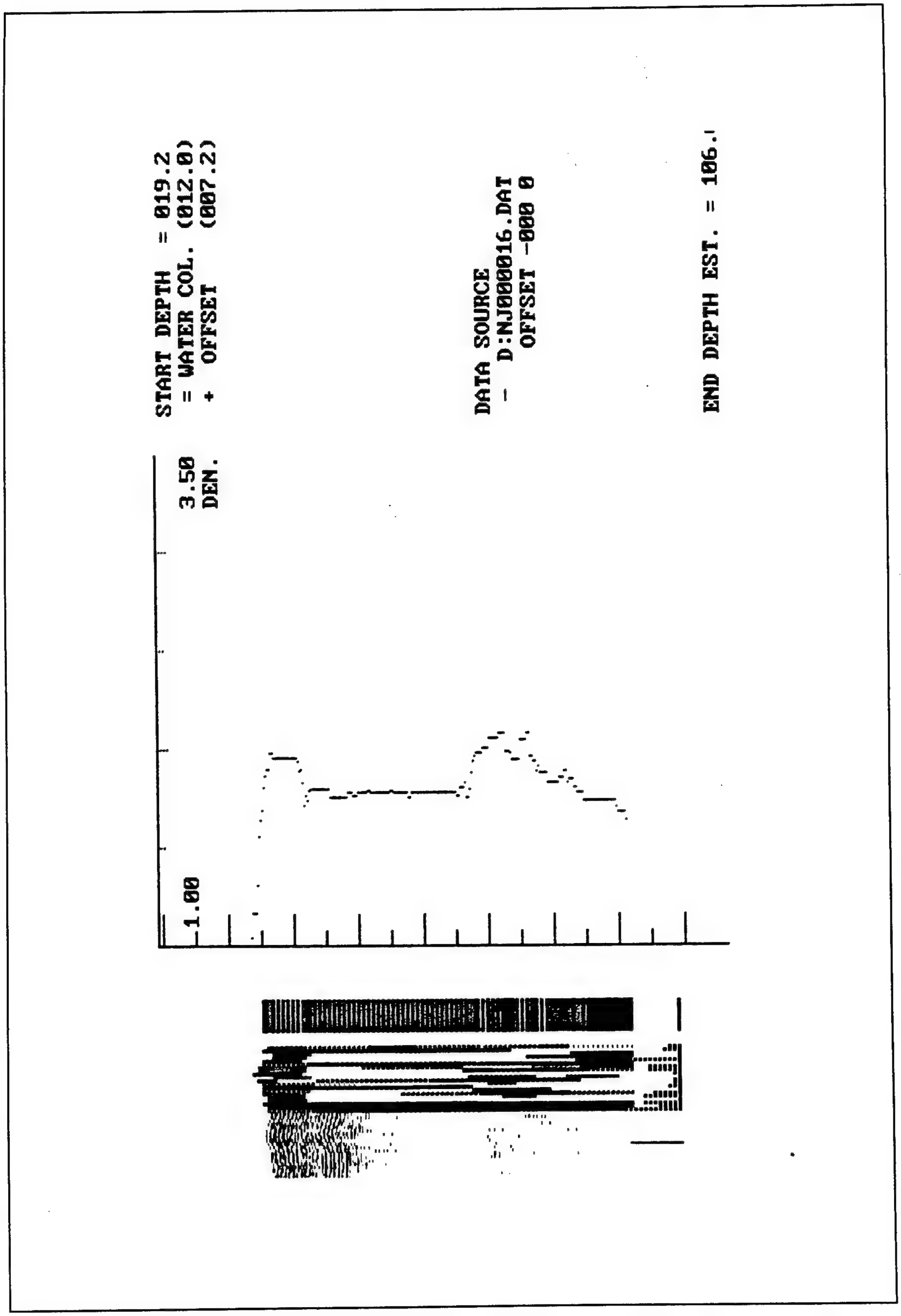
- d:nj000025.DAT
OFFSET -000 1
END DEPTH EST. = 106.
3.50
DEN.
1.00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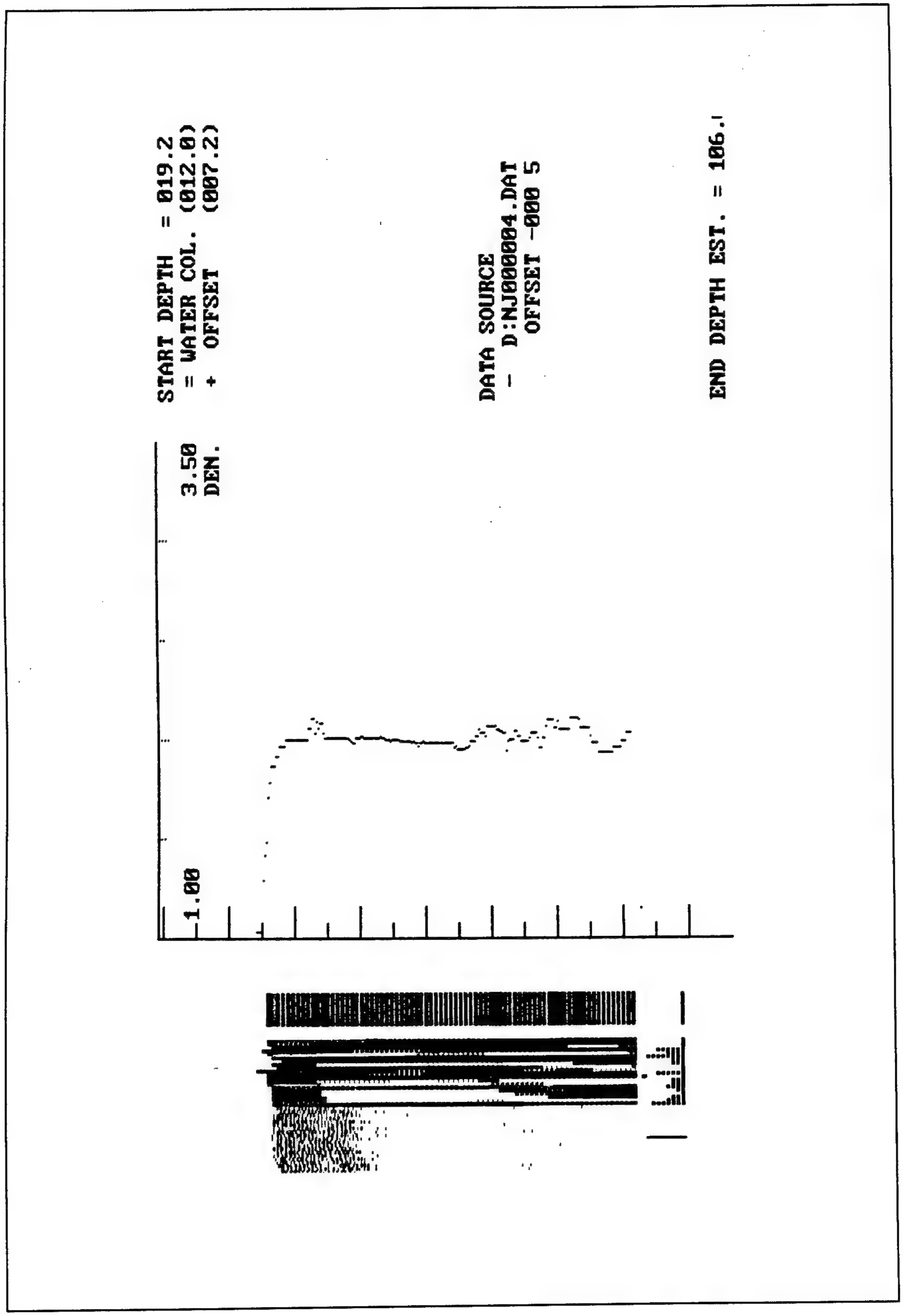
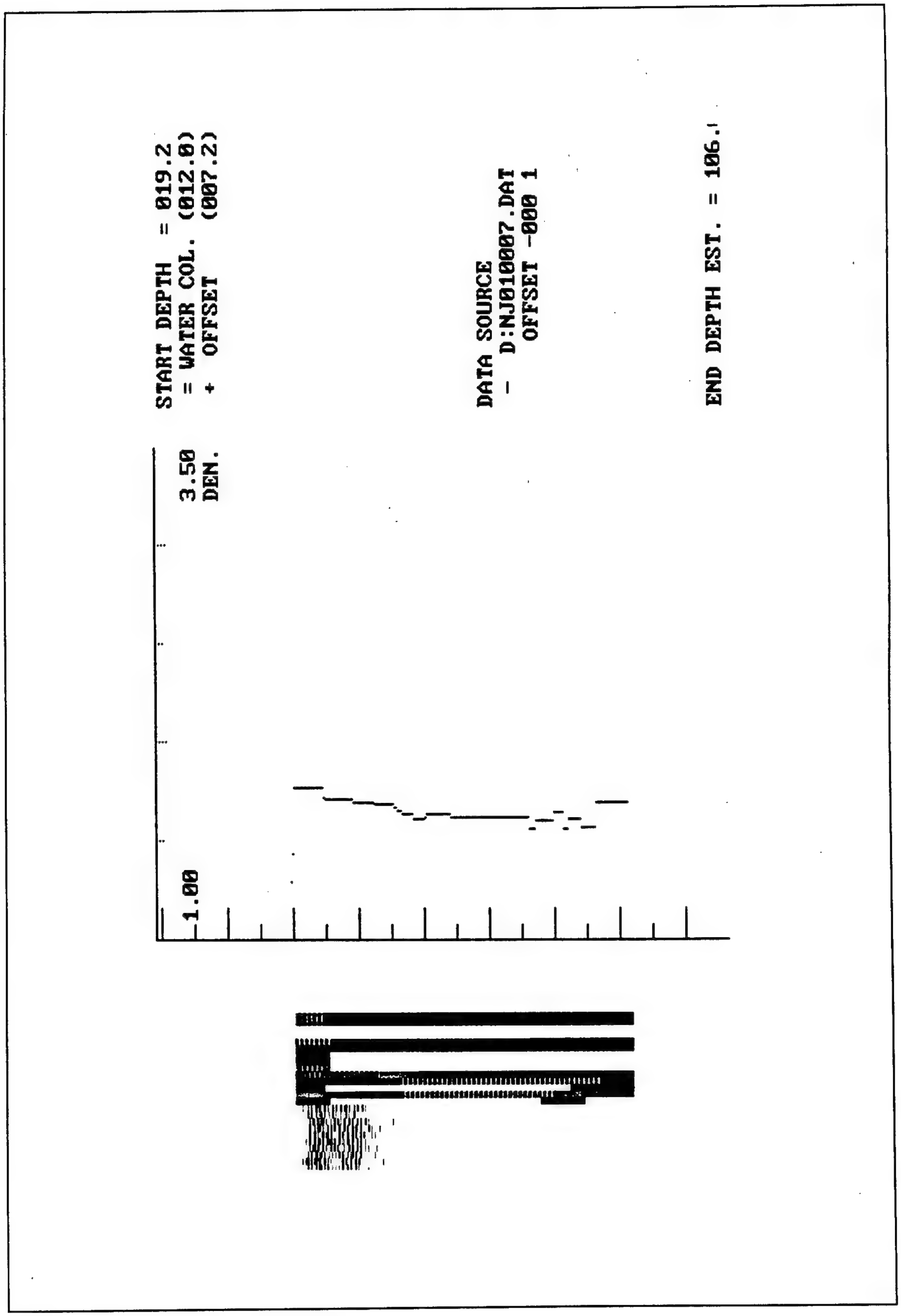
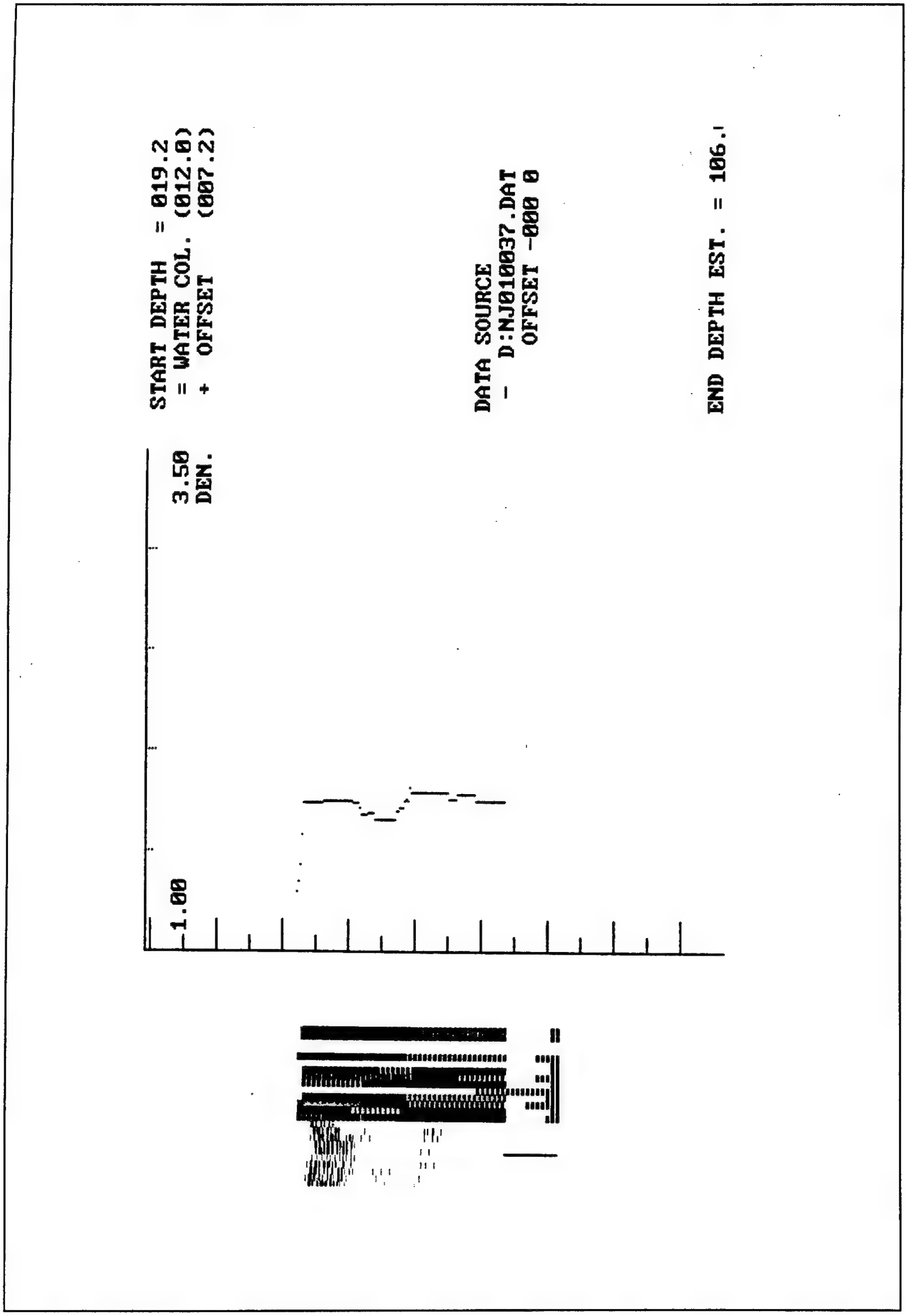
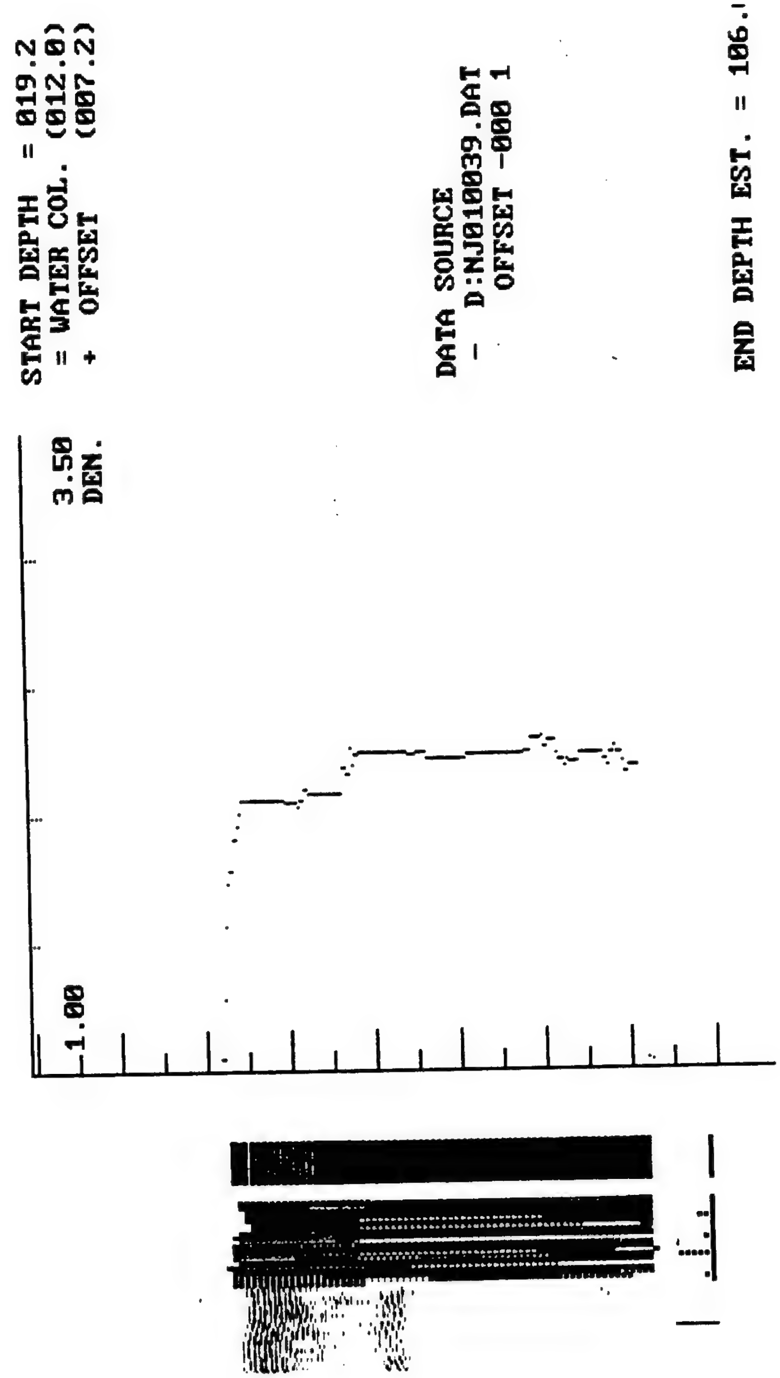
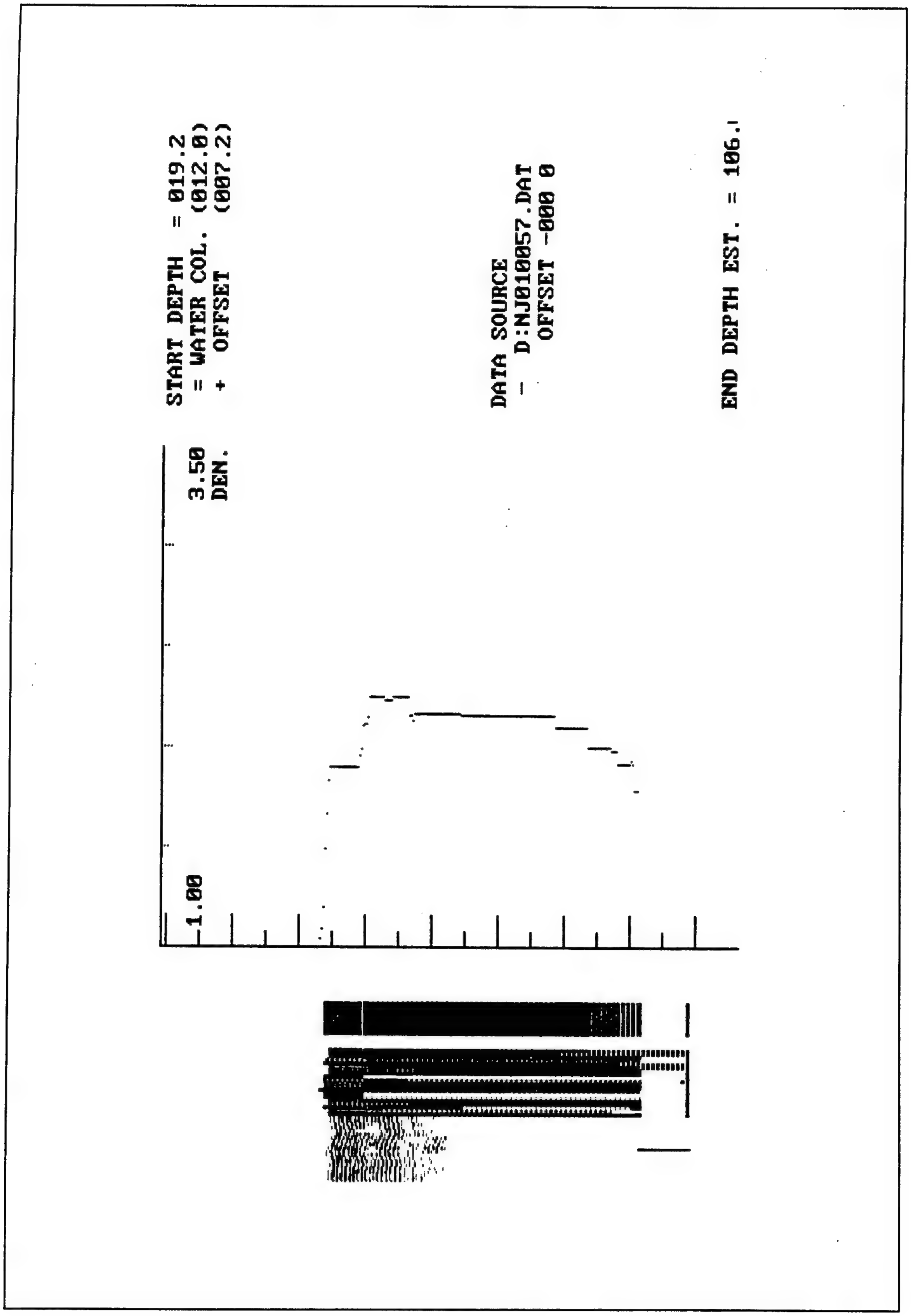
= WATER COL. (012.0)
+ OFFSET (007.2)
3.50
DEN.
1.00
DATA SOURCE
- D:NJ000016.DAT
OFFSET -000 0
END DEPTH EST. = 106.

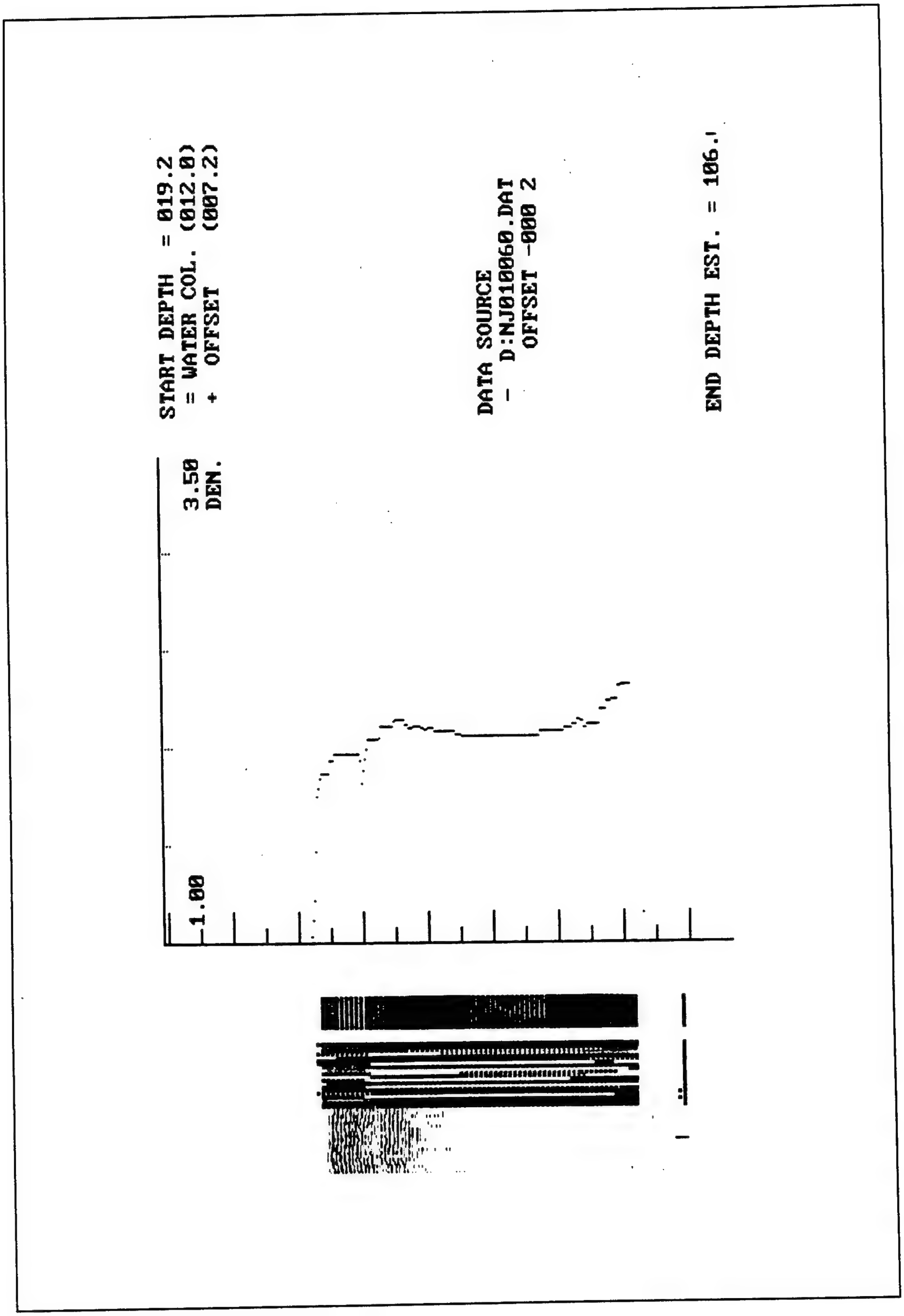

START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ000004.DAT
OFFSET -000 5
END DEPTH EST. = 106.!
3.50
DEN.
1.00

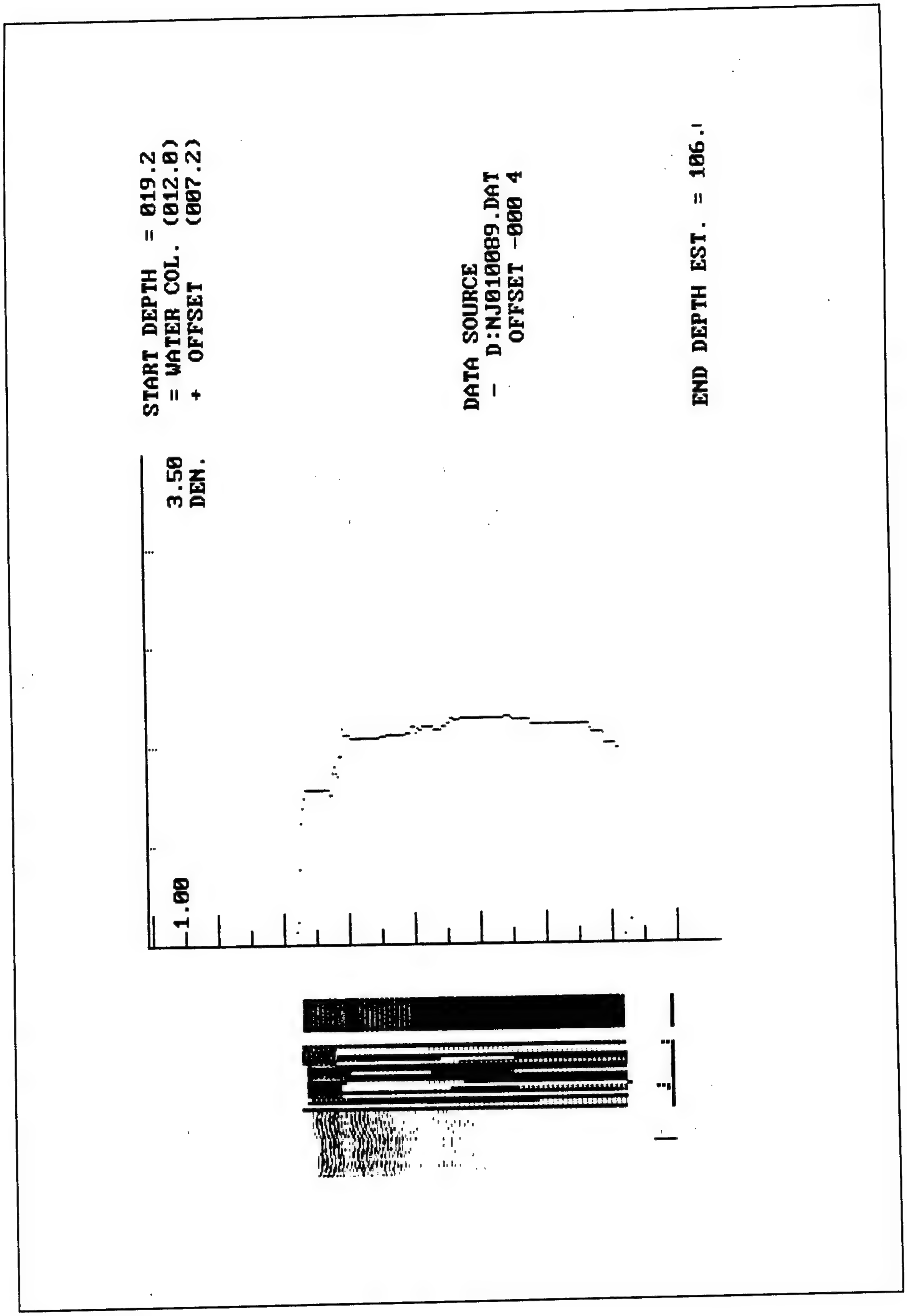

START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ010007.DAT
OFFSET -000 1
END DEPTH EST. = 106.
3.50
DEN.
1.00


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ010037.DAT
OFFSET -000 0
END DEPTH EST. = 106.
3.50
DEN.
1.00

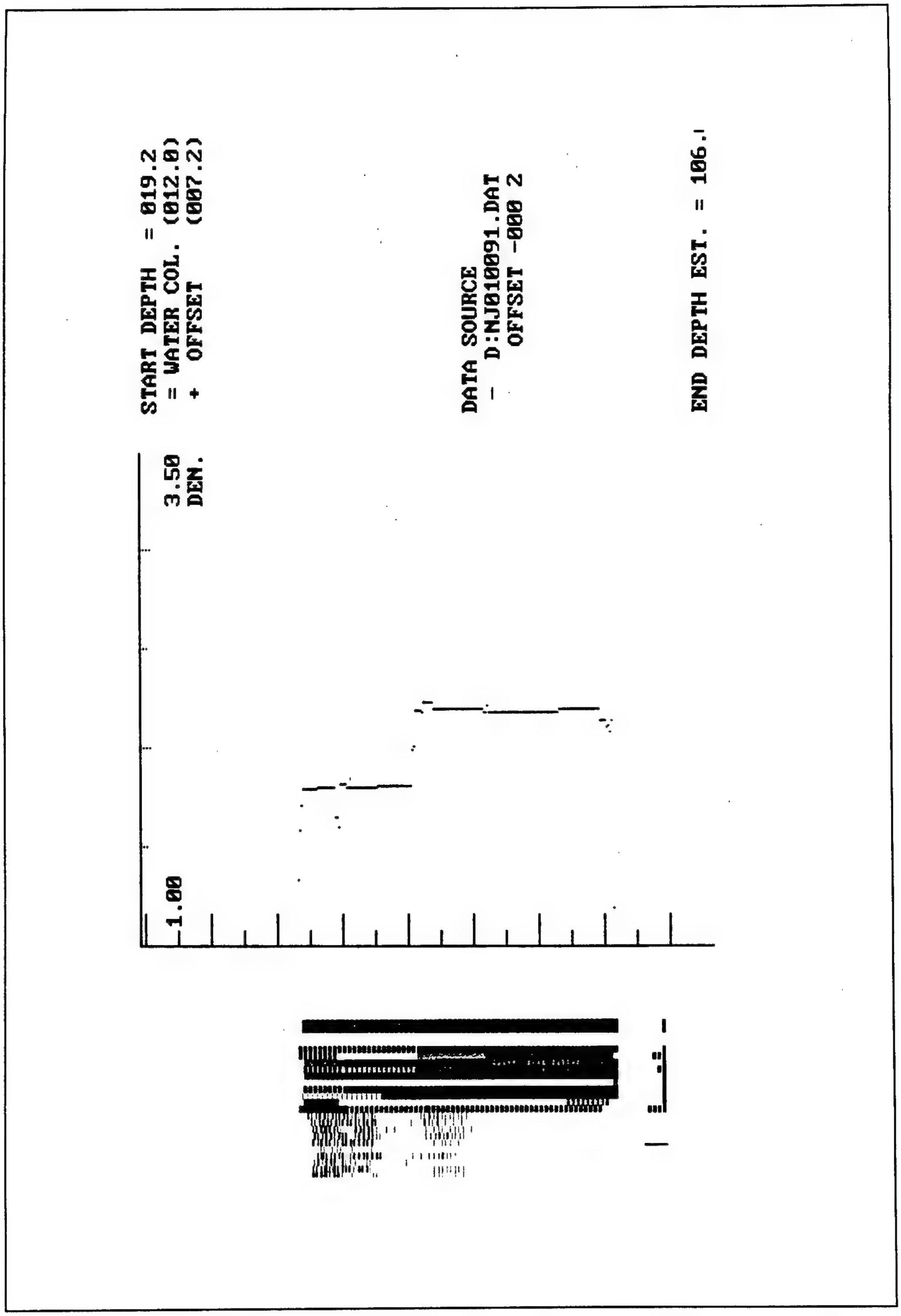

START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ010039.DAT
OFFSET -000 1
END DEPTH EST. = 106.
3.50
DEN.
1.00

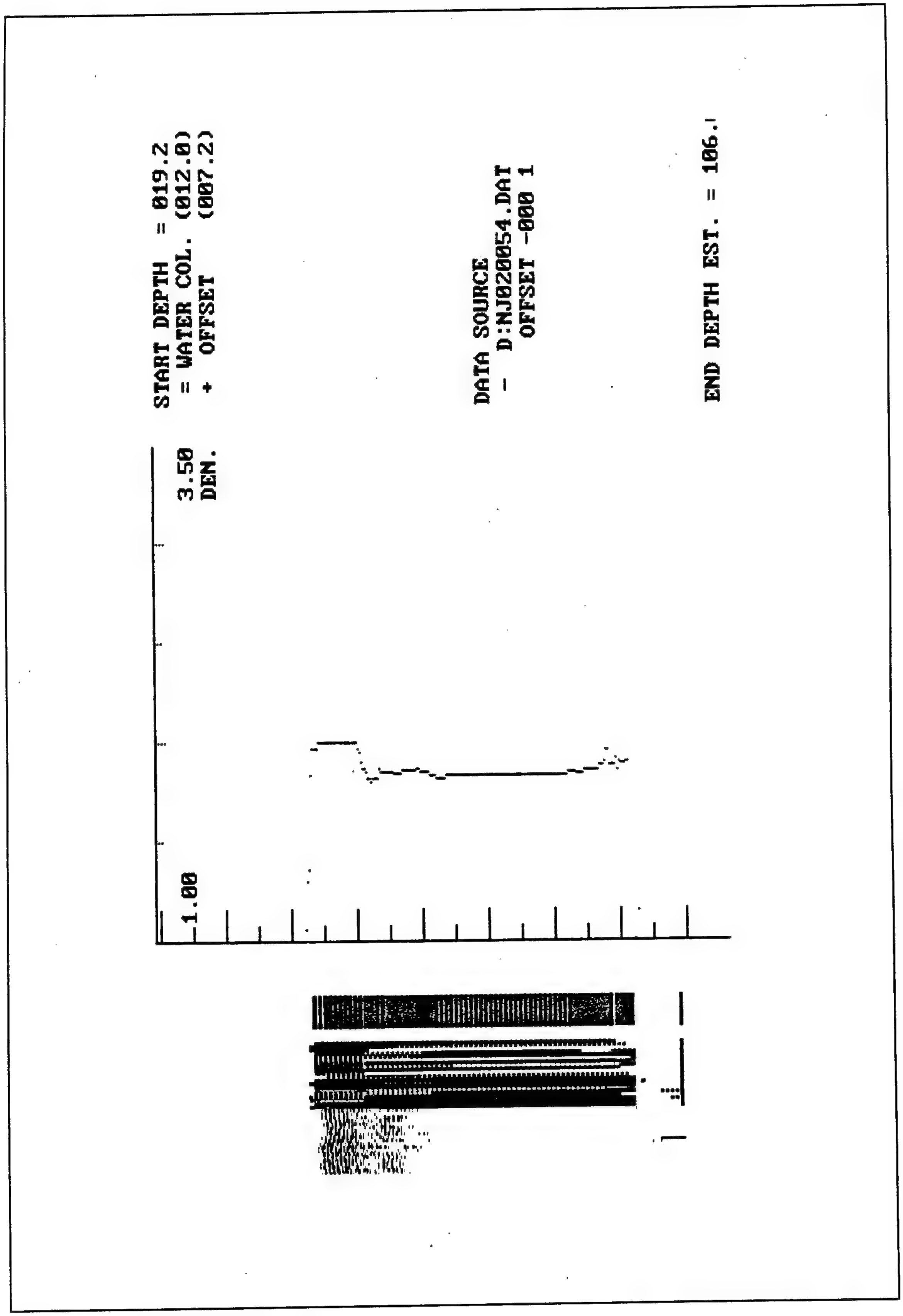

START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ010057.DAT
OFFSET -000 0
END DEPTH EST. = 106.
3.50
DEN.
1.00


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
3.50
DEN.
1.00
DATA SOURCE
- D:NJ010060.DAT
OFFSET -000 2
END DEPTH EST. = 106.



START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ010089.DAT
OFFSET -000 4
END DEPTH EST. = 106.
3.50
DEN.
1.00


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ010091.DAT
OFFSET -000 2
END DEPTH EST. = 106.
3.50
DEN.
1.00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= WATER COL. (012.0)
+ OFFSET (007.2)
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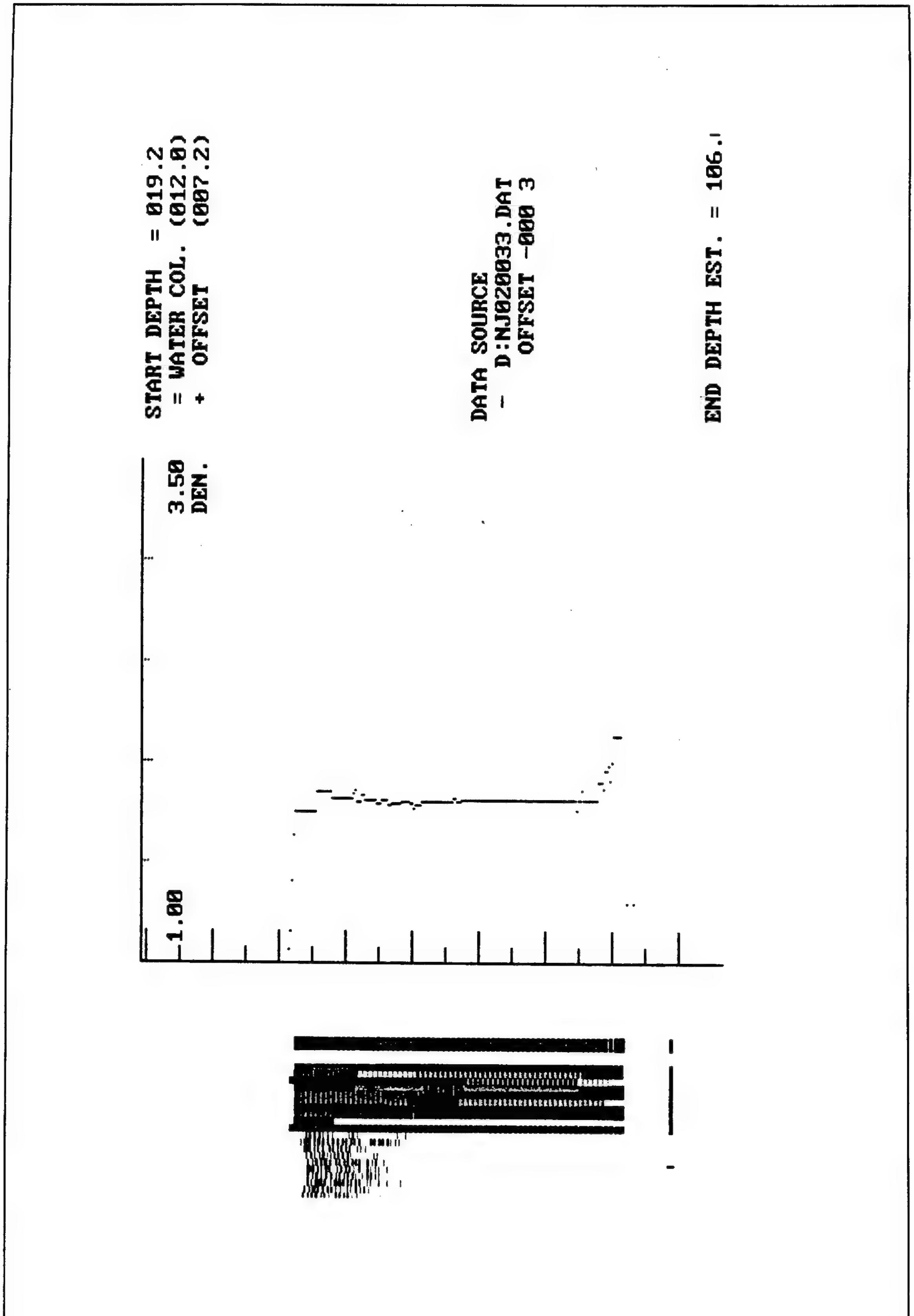
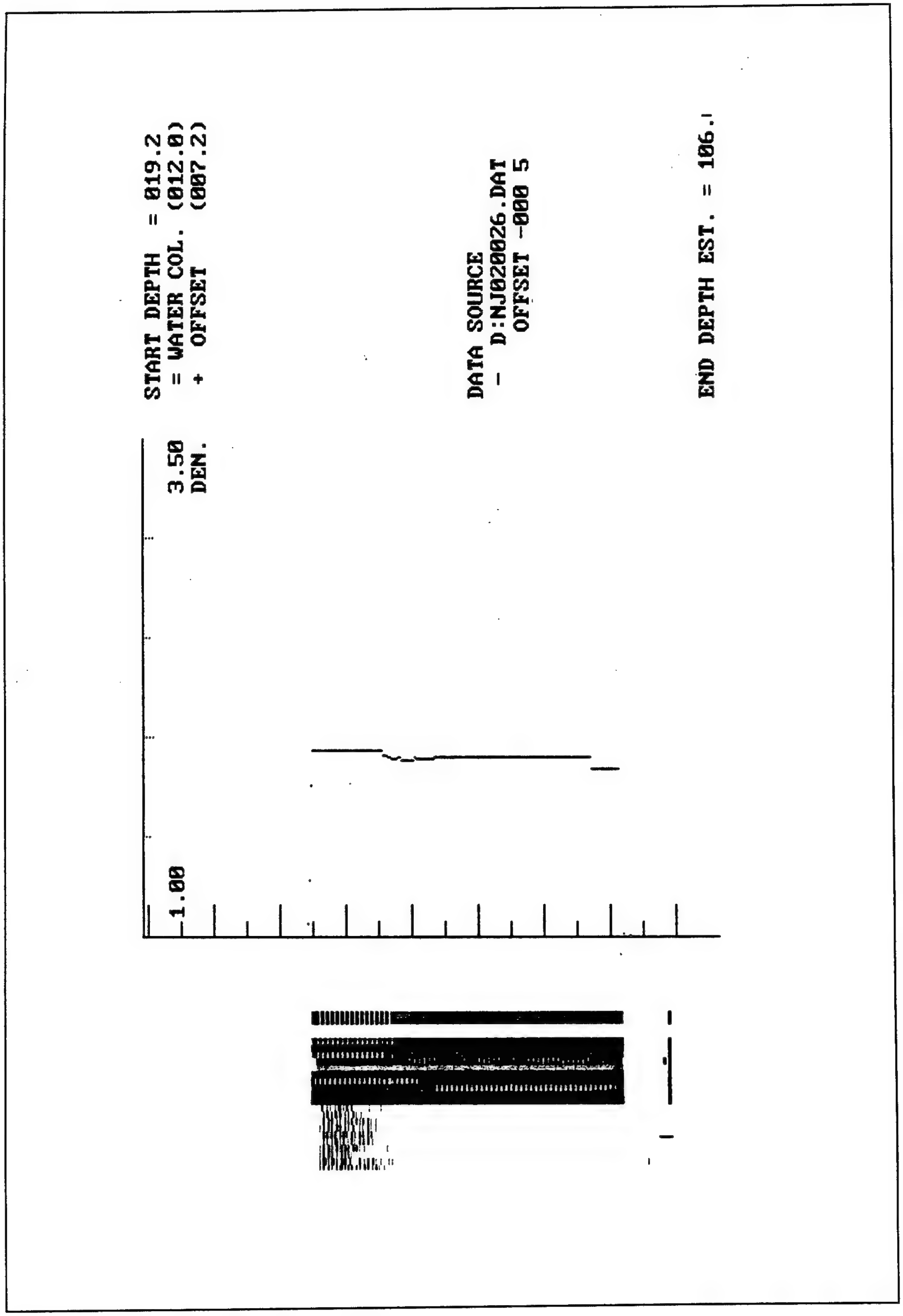
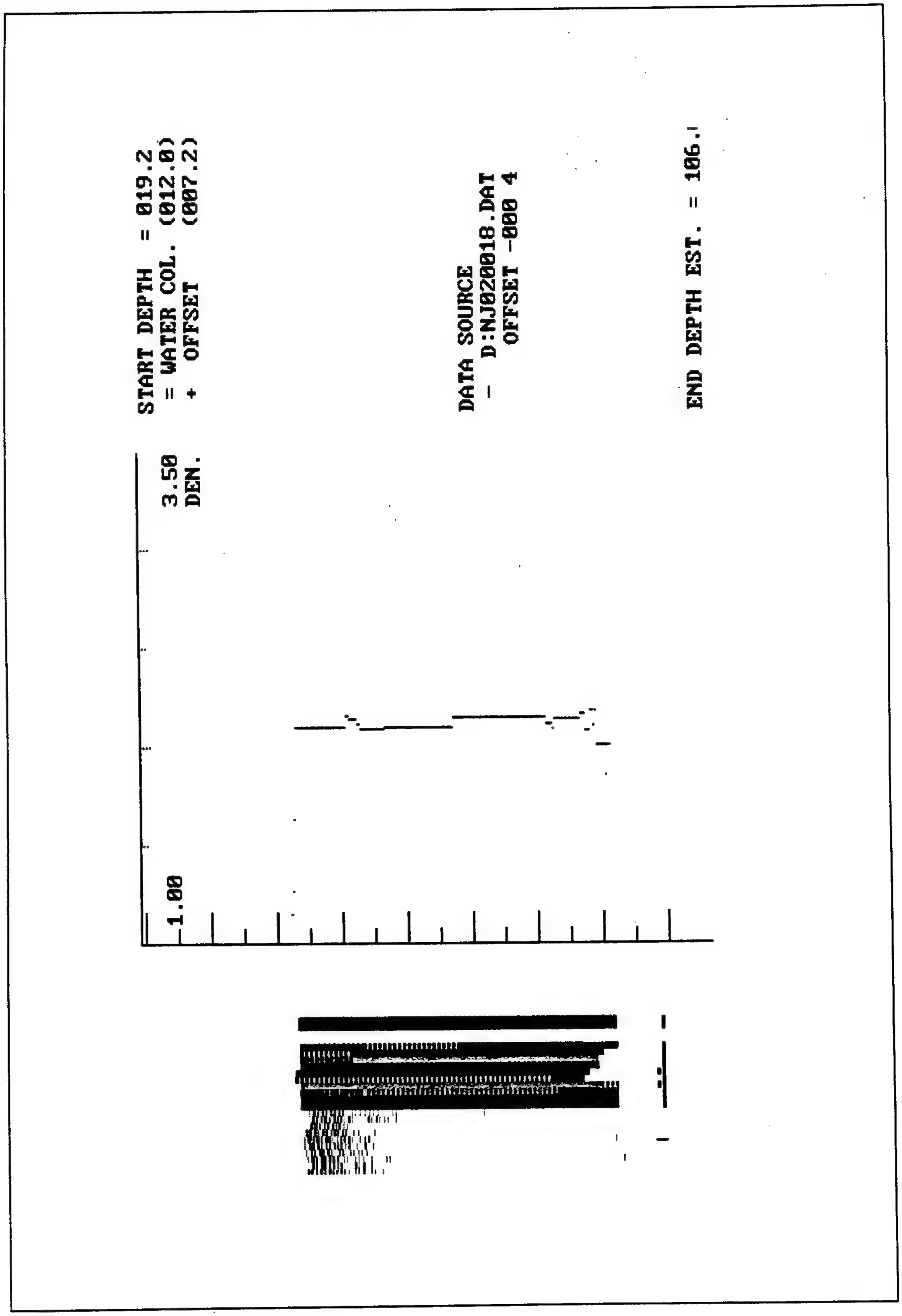
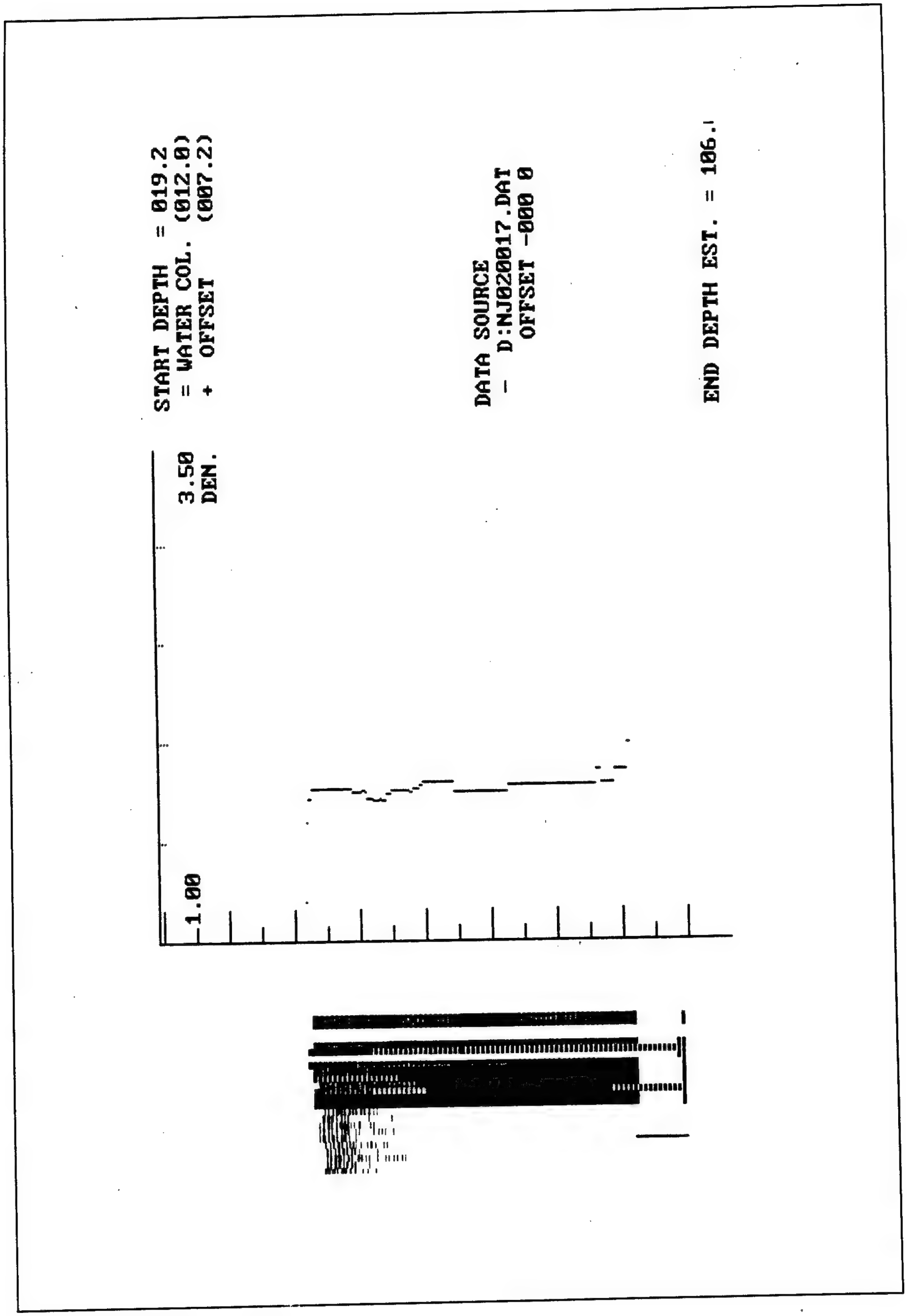
- D:NJ020054.DAT
OFFSET -000 1
END DEPTH EST. = 106.
3.50
DEN.
1.00


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ020033.DAT
OFFSET -000 3
END DEPTH EST. = 106.
3.50
DEN.
1.00


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
3.50
DEN.
1.00
DATA SOURCE
- D:NJ020026.DAT
OFFSET -000 5
END DEPTH EST. = 106.1


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
DATA SOURCE
- D:NJ020018.DAT
OFFSET -000 4
END DEPTH EST. = 106.
3.50
DEN.
1.00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+ OFFSET (007.2)
DATA SOURCE
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OFFSET -000 0
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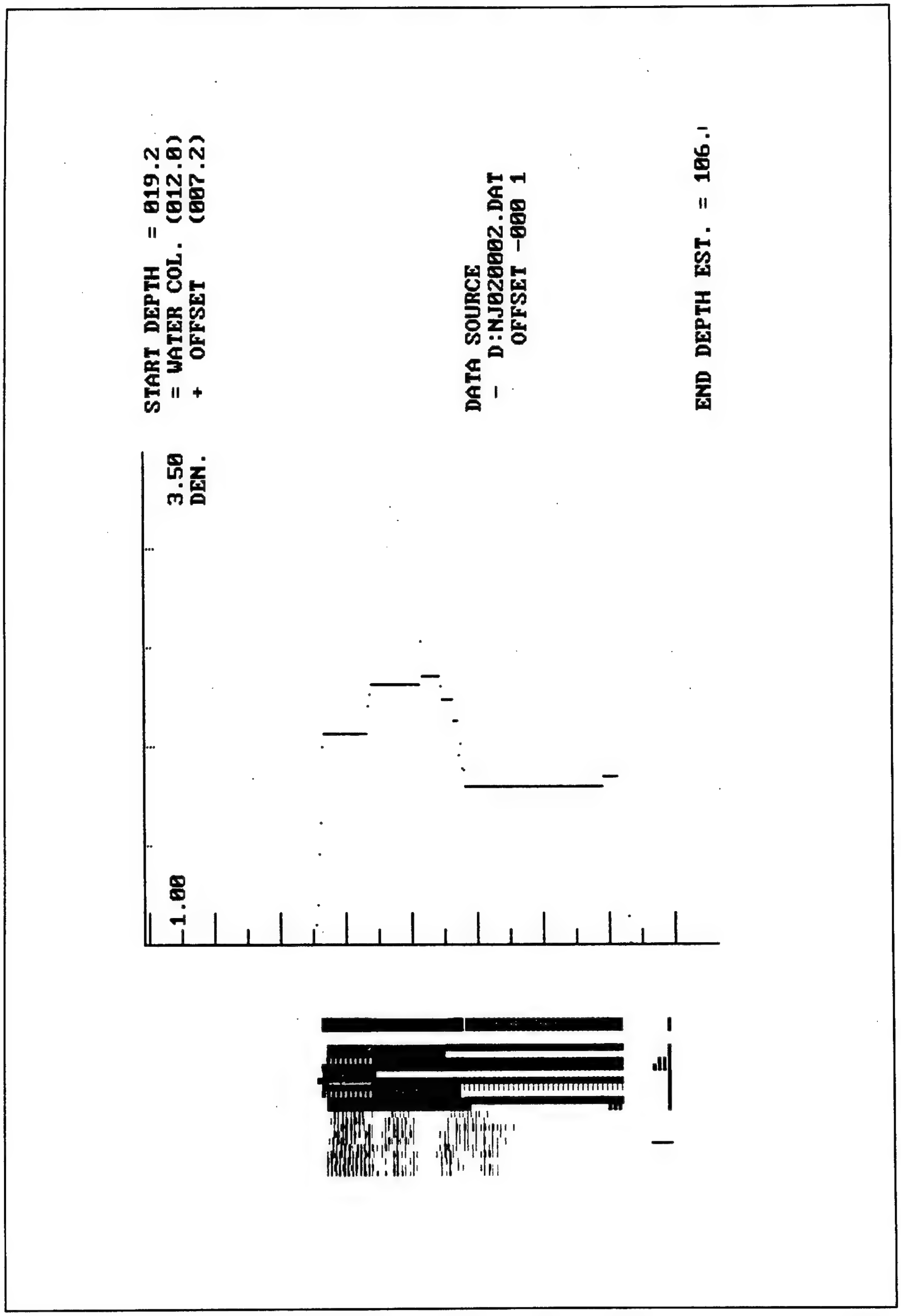
3.50
DEN.
1.00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+ OFFSET (007.2)
3.50
DEN.
1.00
DATA SOURCE
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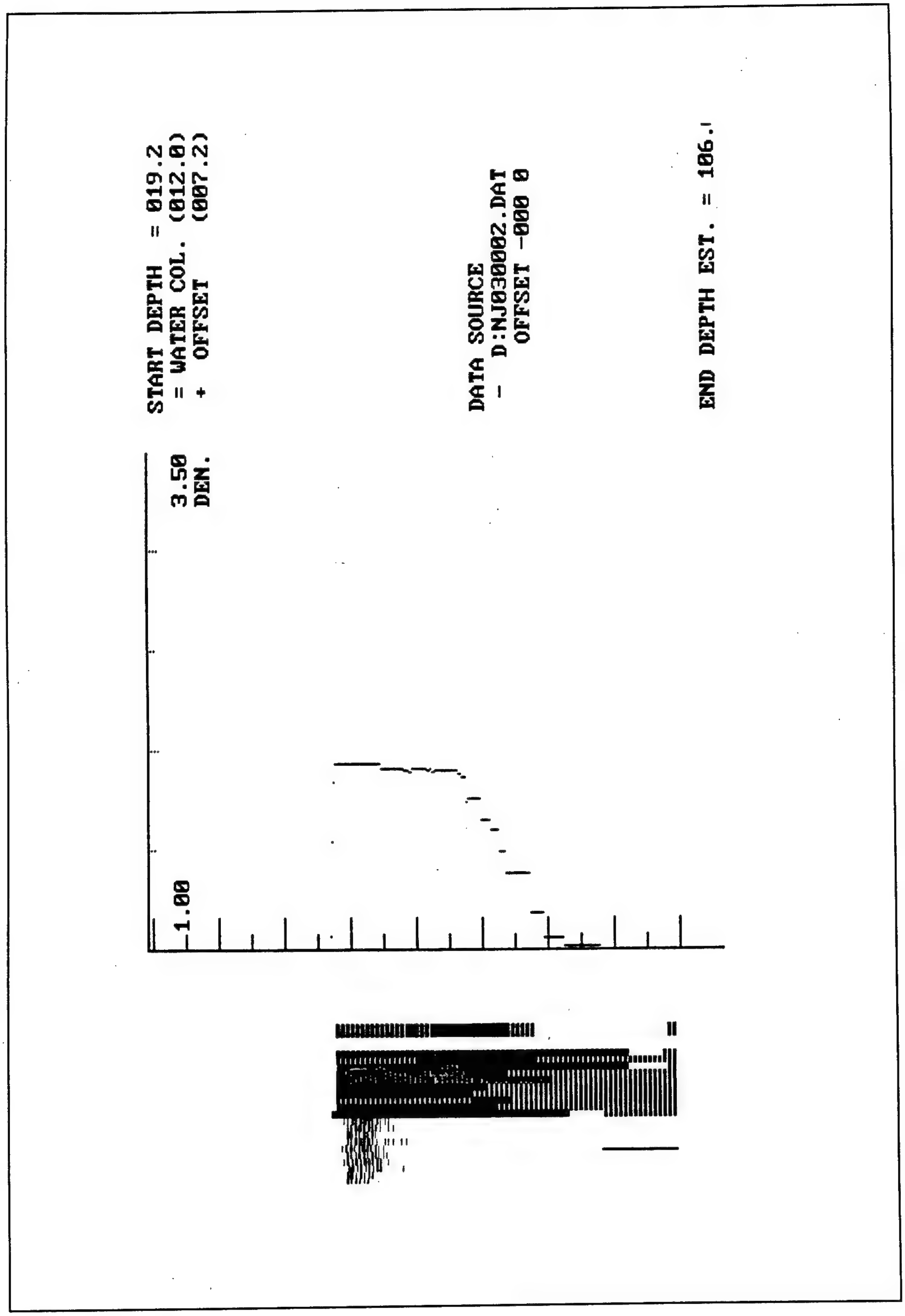
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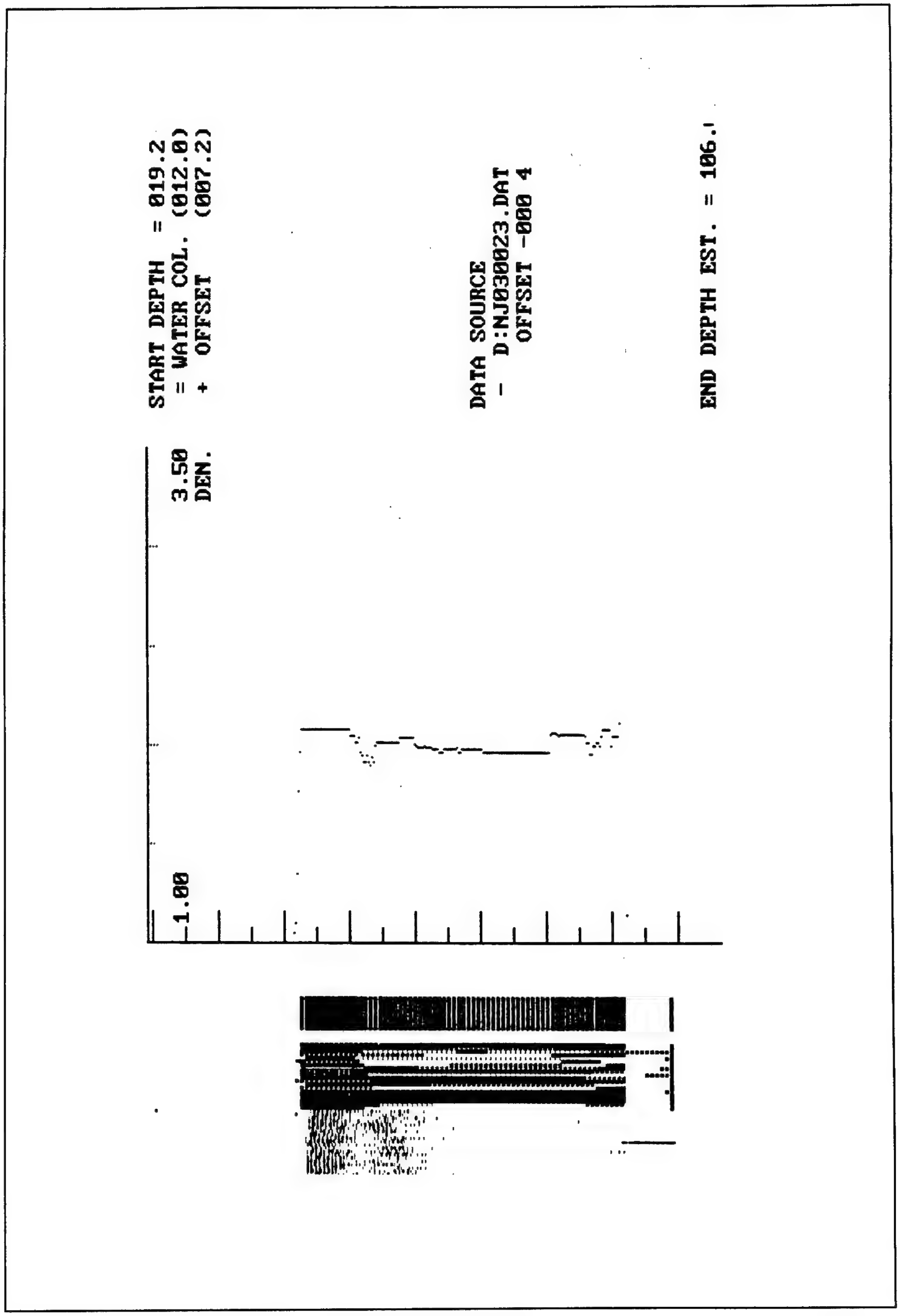
3.50
DEN.
1.00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= WATER COL. (012.0)
+ OFFSET (007.2)
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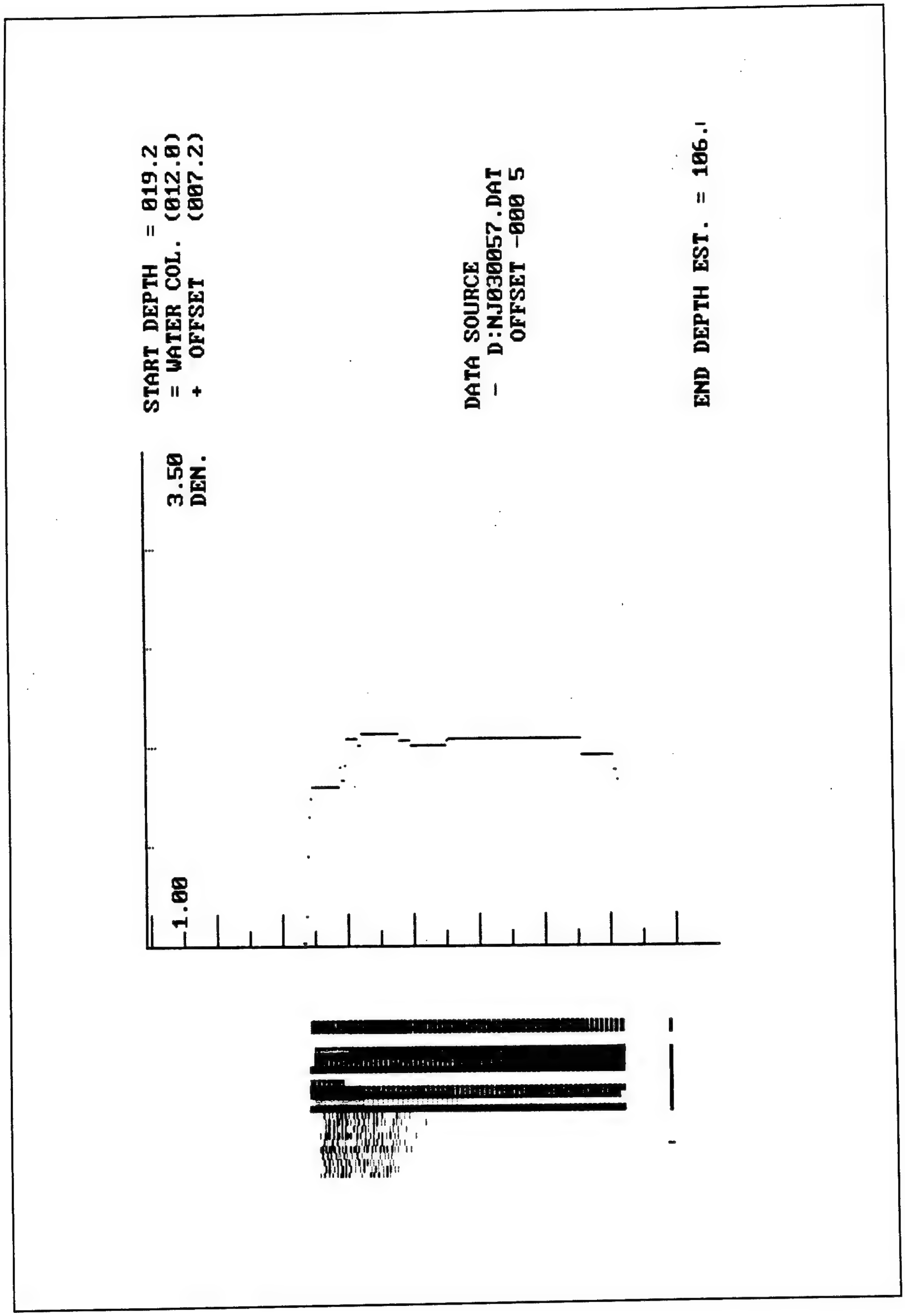
END DEPTH EST. = 106.!
3.50
DEN.
1.00


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
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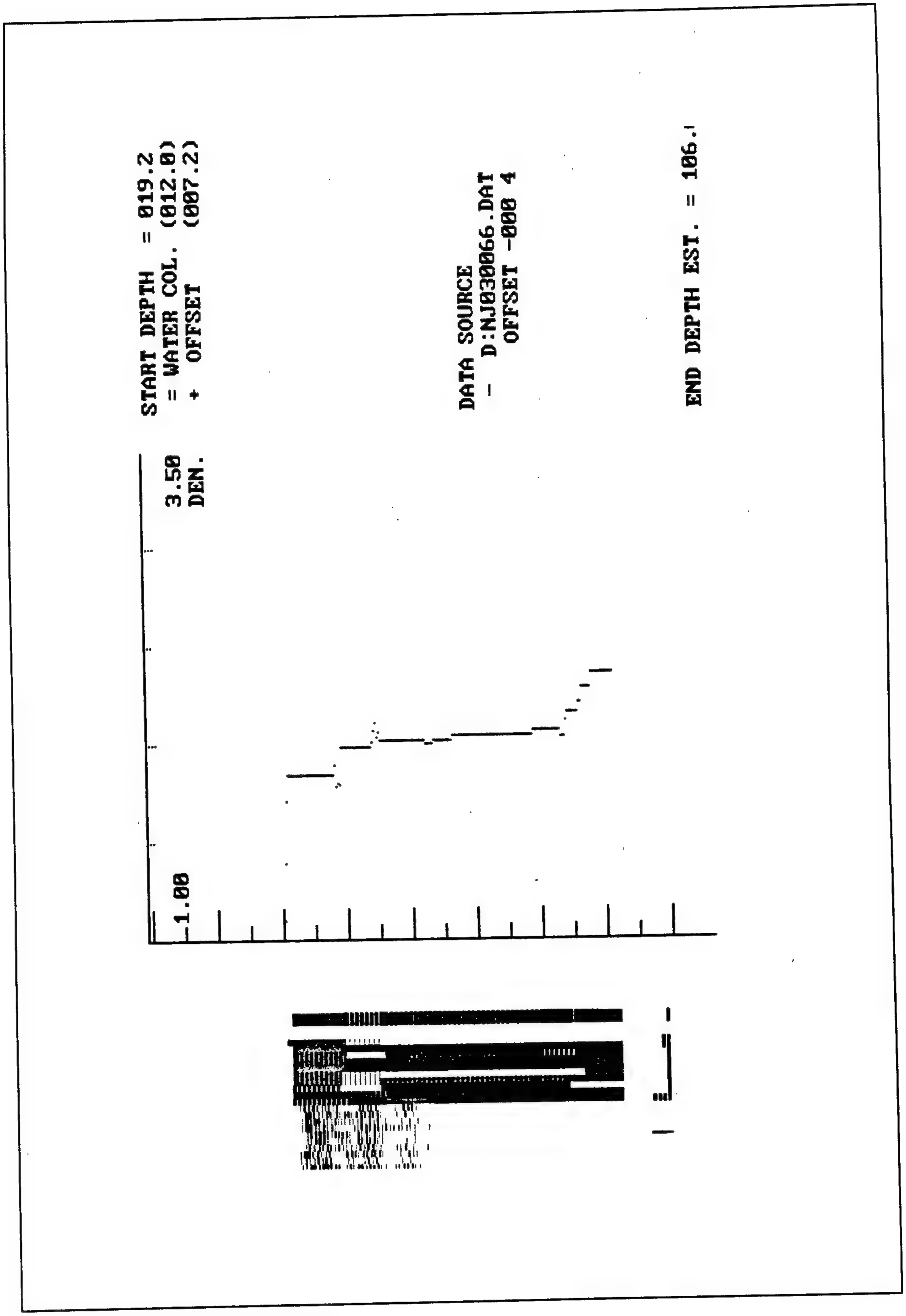
END DEPTH EST. = 106.!
3.50
DEN.
1.00


START DEPTH = 019.2
= WATER COL. (012.0)
+ OFFSET (007.2)
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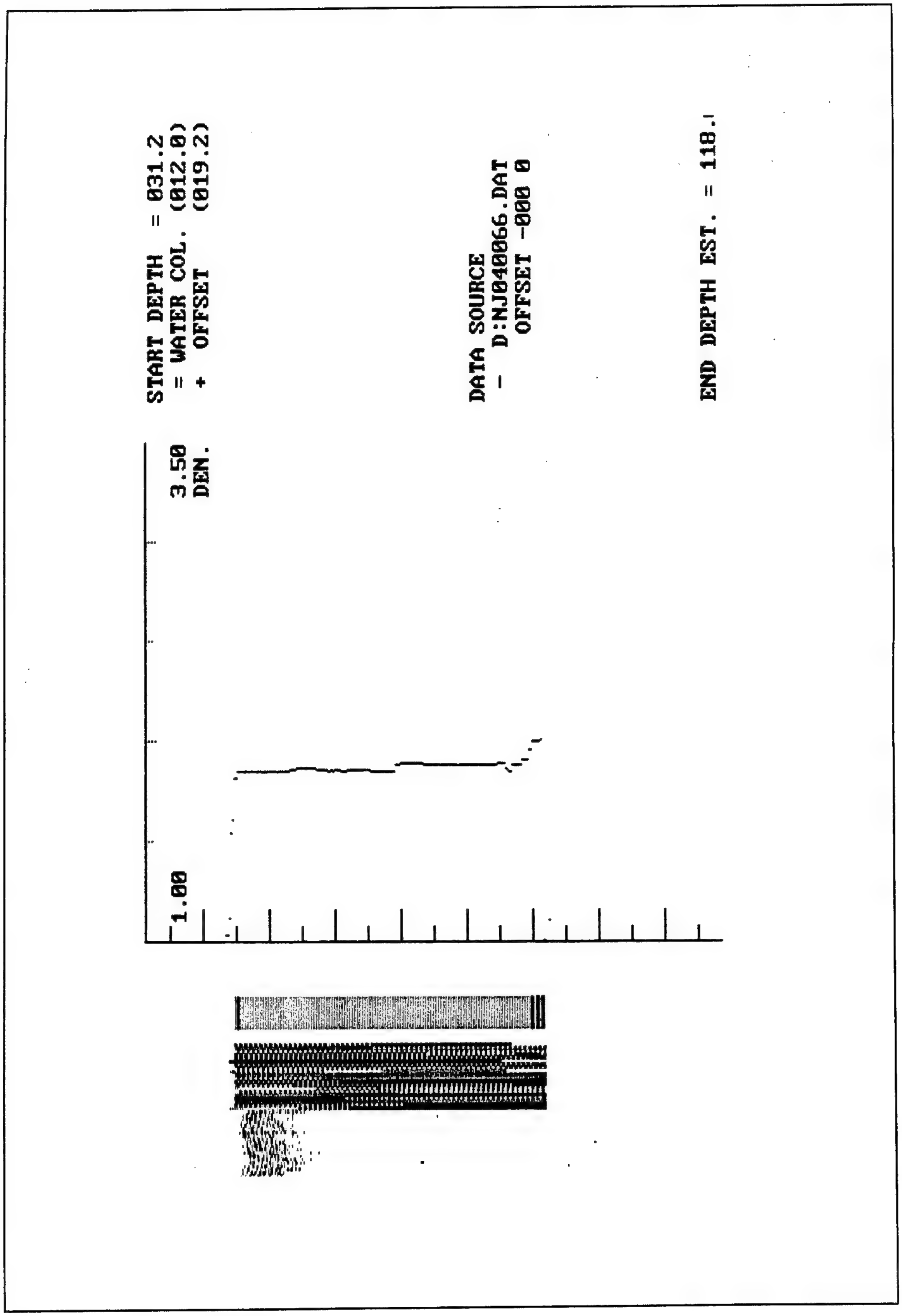
- D:NJ030066.DAT
OFFSET -000 4
END DEPTH EST. = 106.!
3.50
DEN.
1.00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+ OFFSET (019.2)
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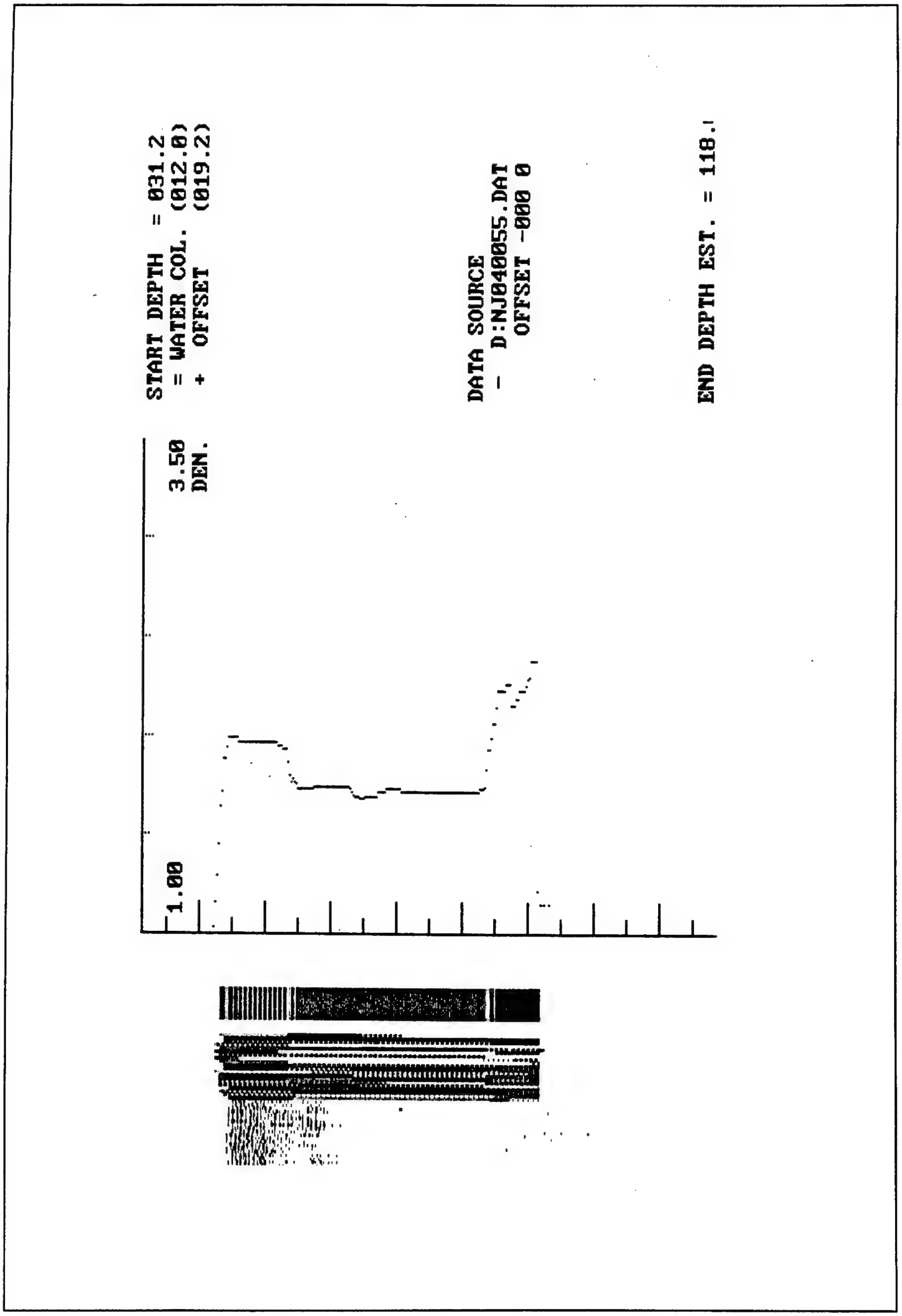
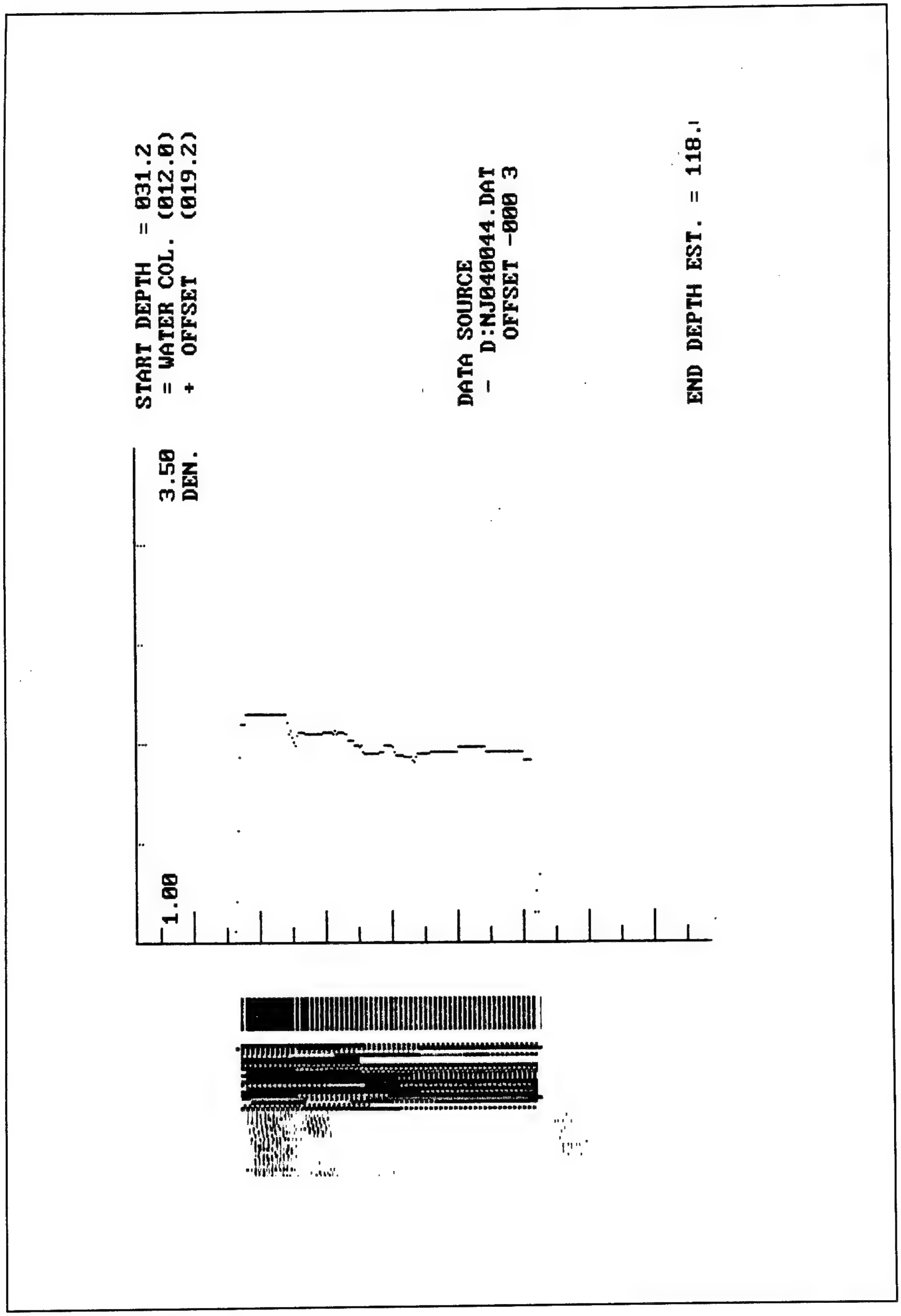
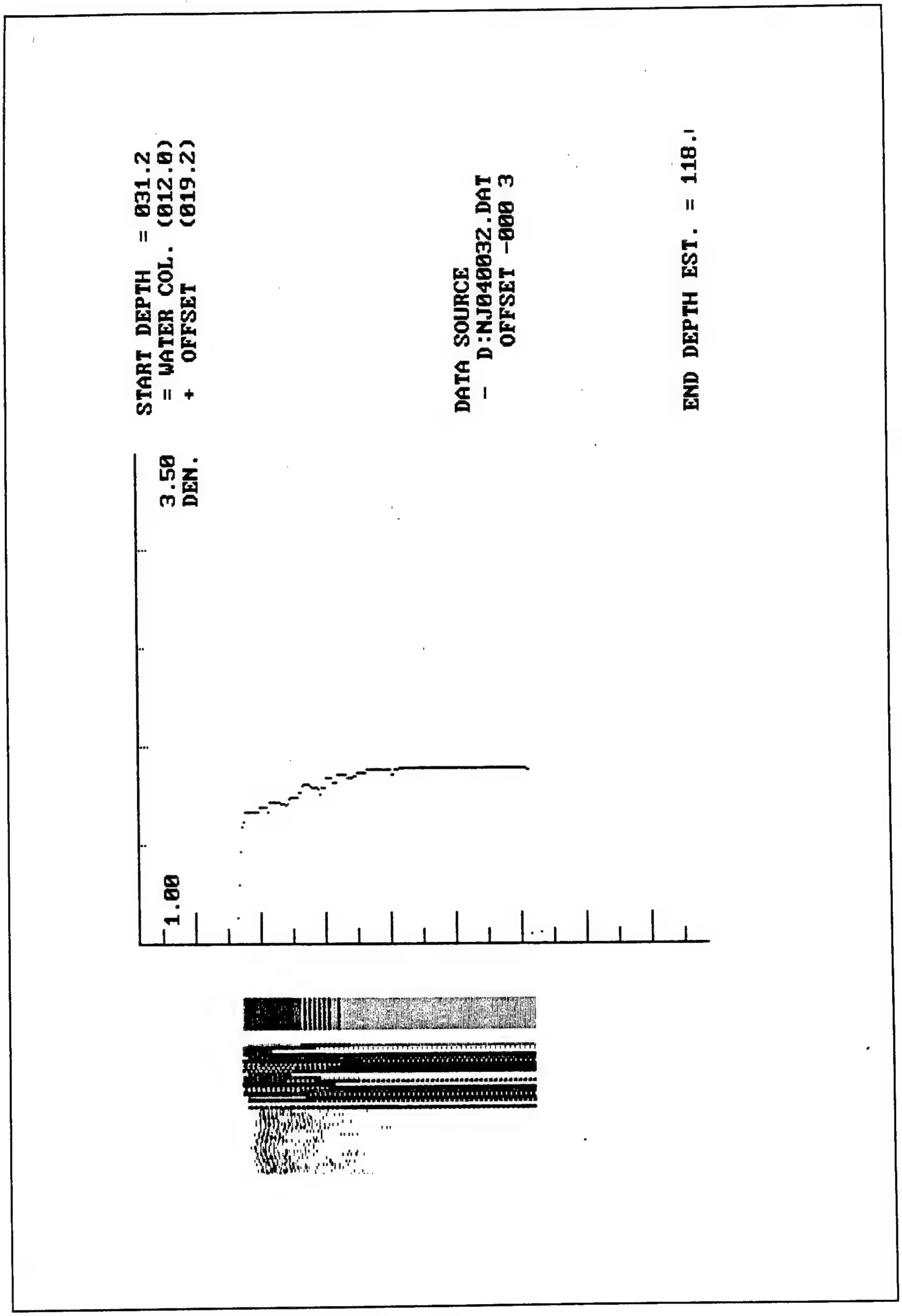
END DEPTH EST. = 118.
3.50
DEN.
1.00


START DEPTH = 031.2
= WATER COL. (012.0)
+ OFFSET (019.2)
DATA SOURCE
- D:NJ040055.DAT
OFFSET -000 0
END DEPTH EST. = 118.
3.50
DEN.
1.00


START DEPTH = 031.2
= WATER COL. (012.0)
+ OFFSET (019.2)
DATA SOURCE
- D:NJ040044.DAT
OFFSET -000 3
END DEPTH EST. = 118.!
3.50
DEN.
1.00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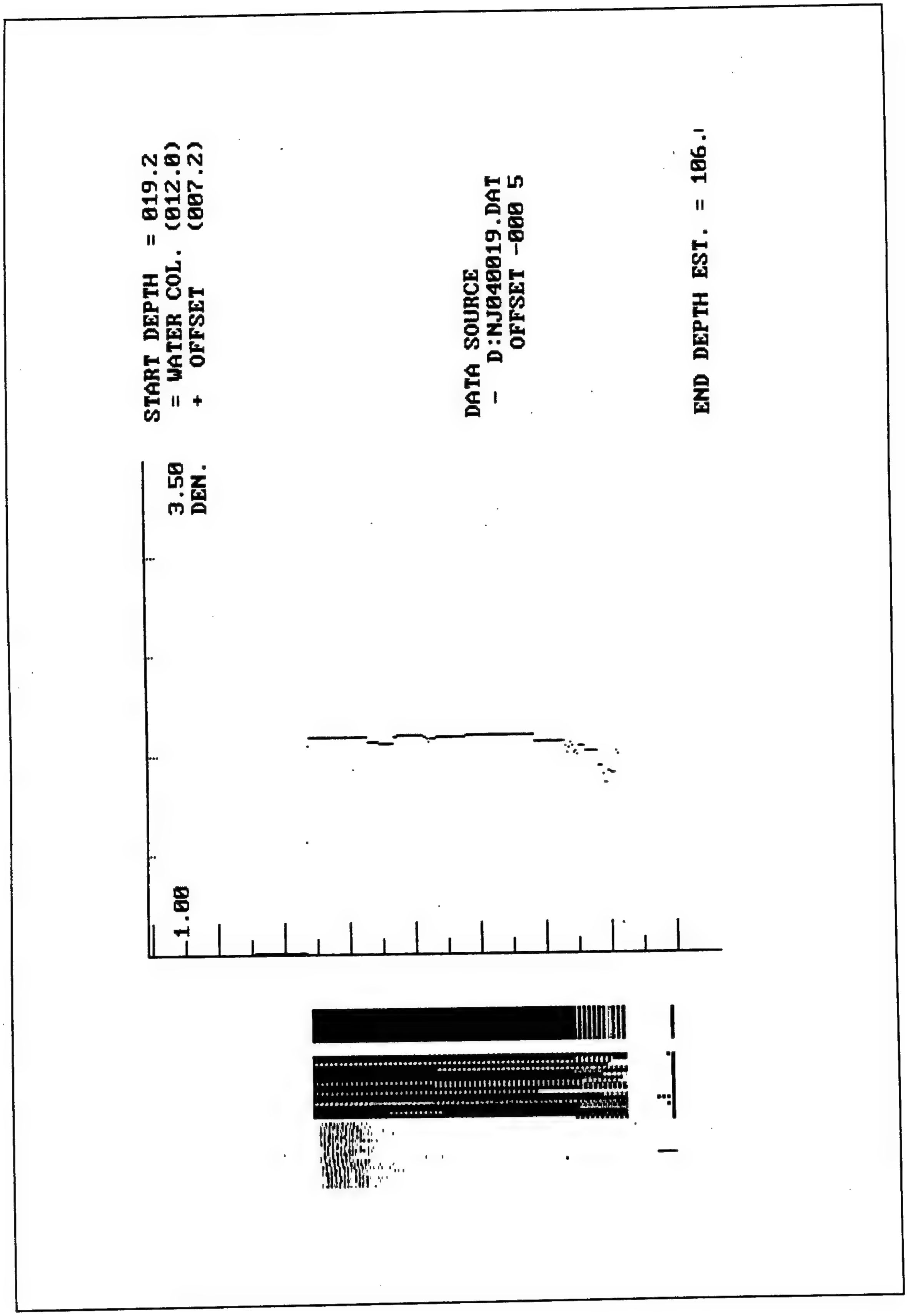
+ OFFSET (019.2)
DATA SOURCE
- D:NJ040032.DAT
OFFSET -000 3
END DEPTH EST. = 118.
3.50
DEN.
1.00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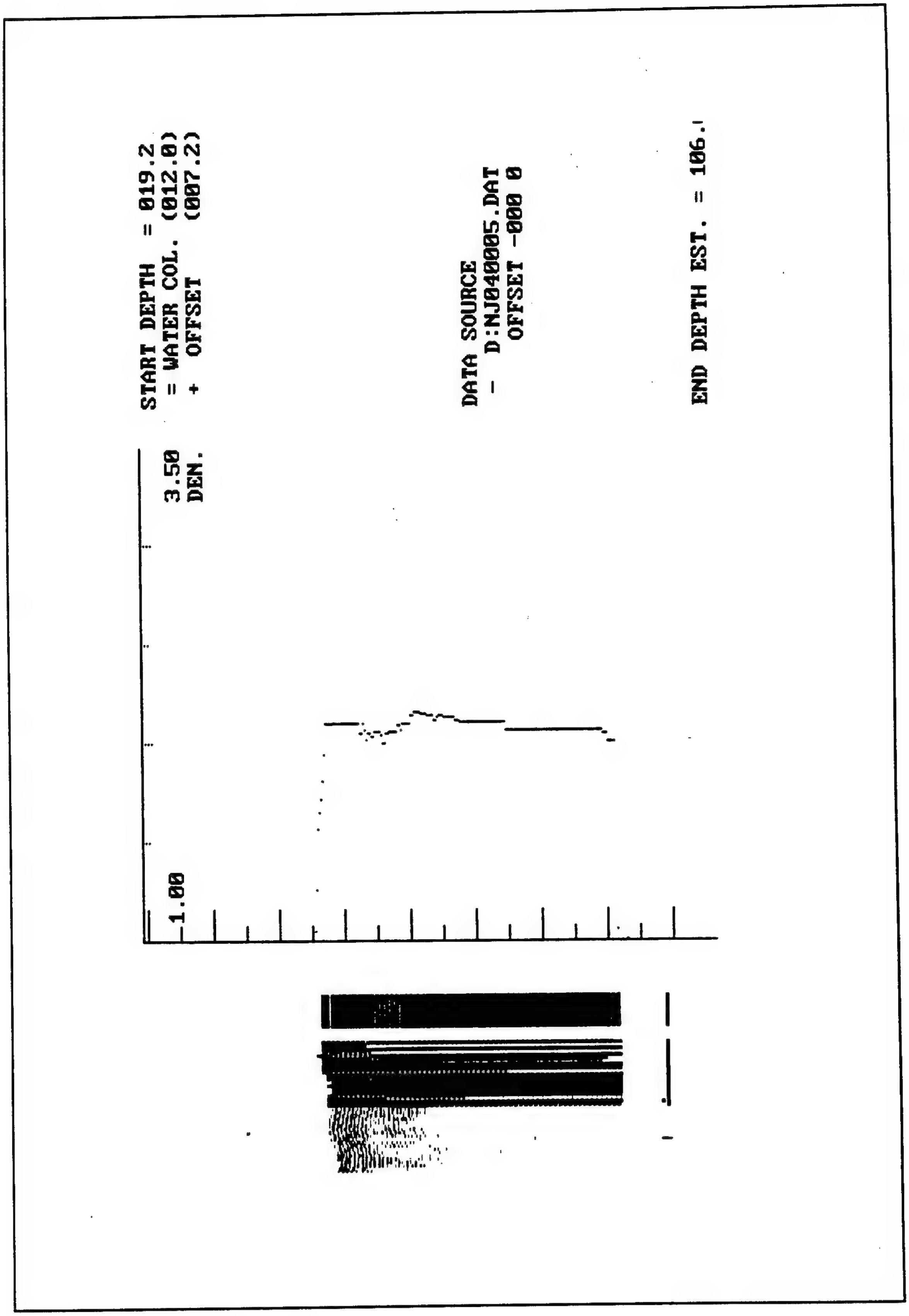
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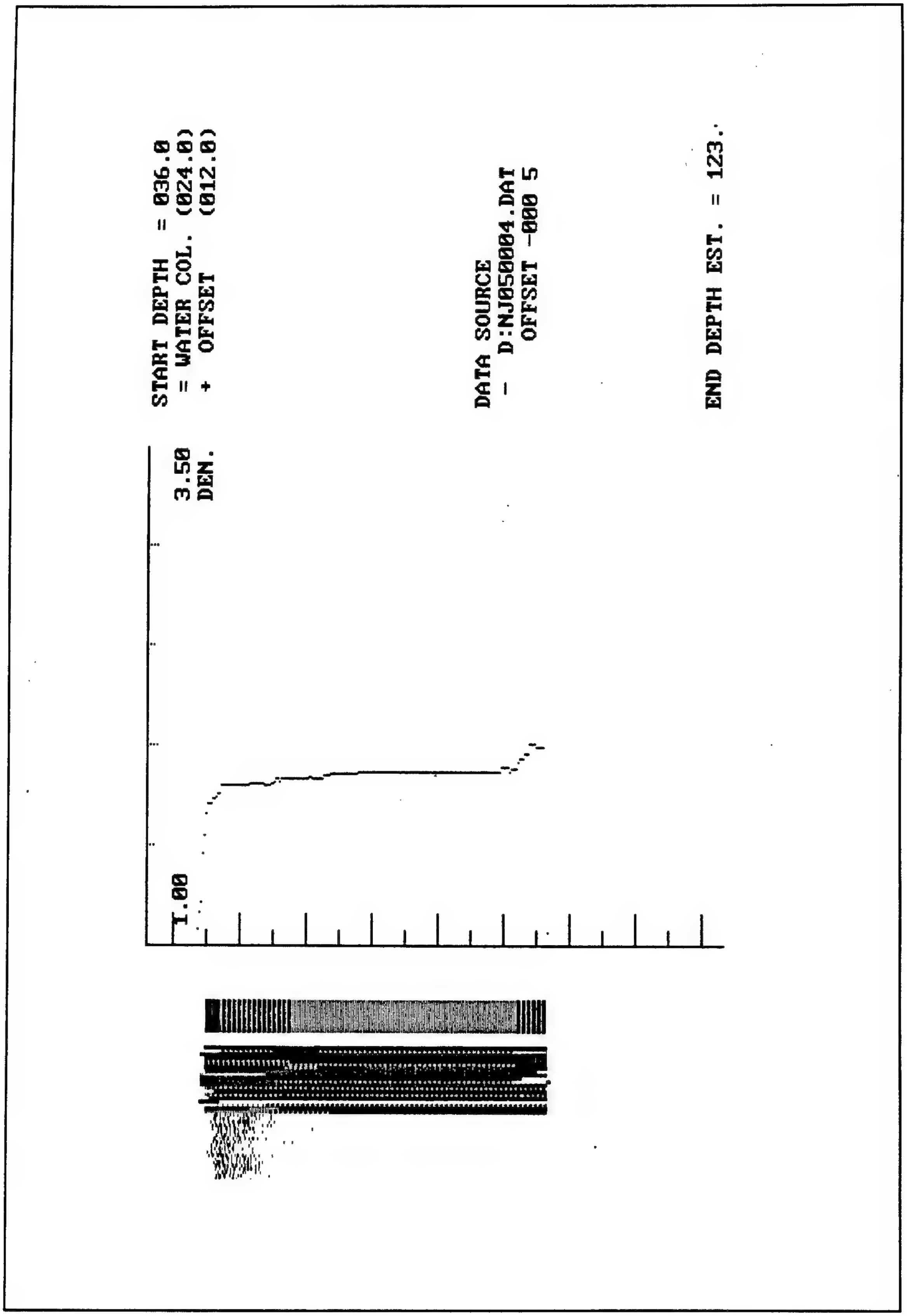
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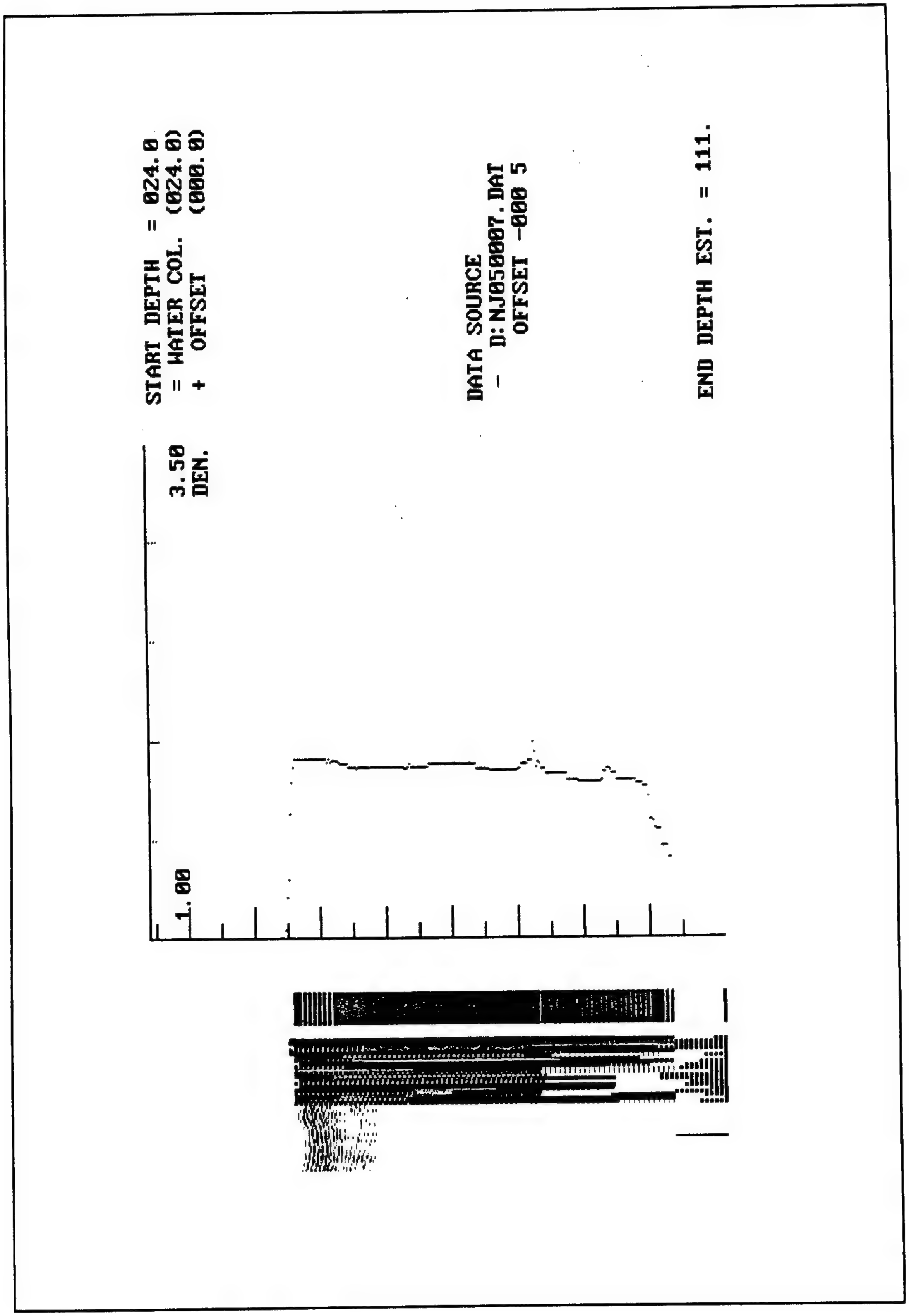
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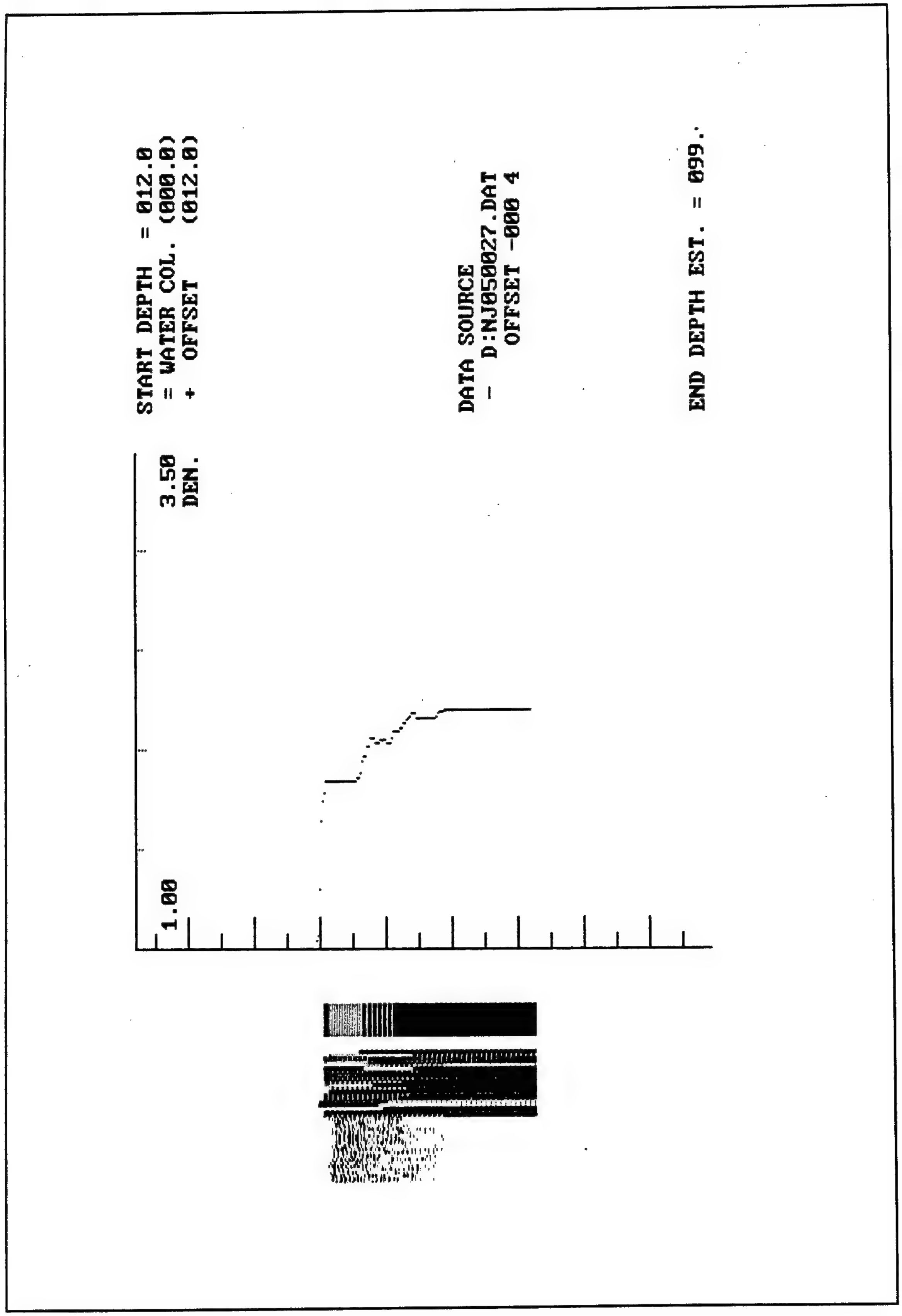
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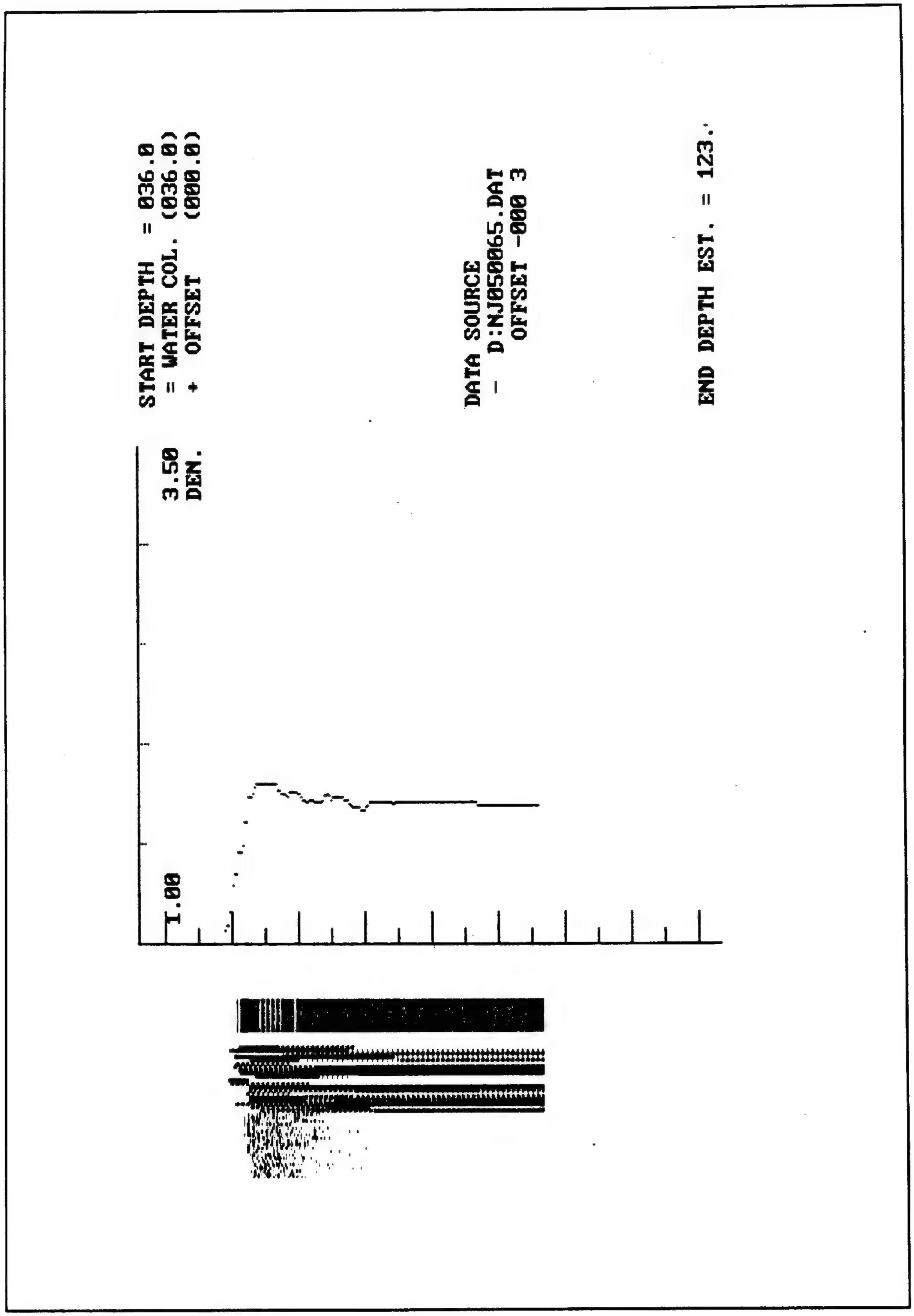
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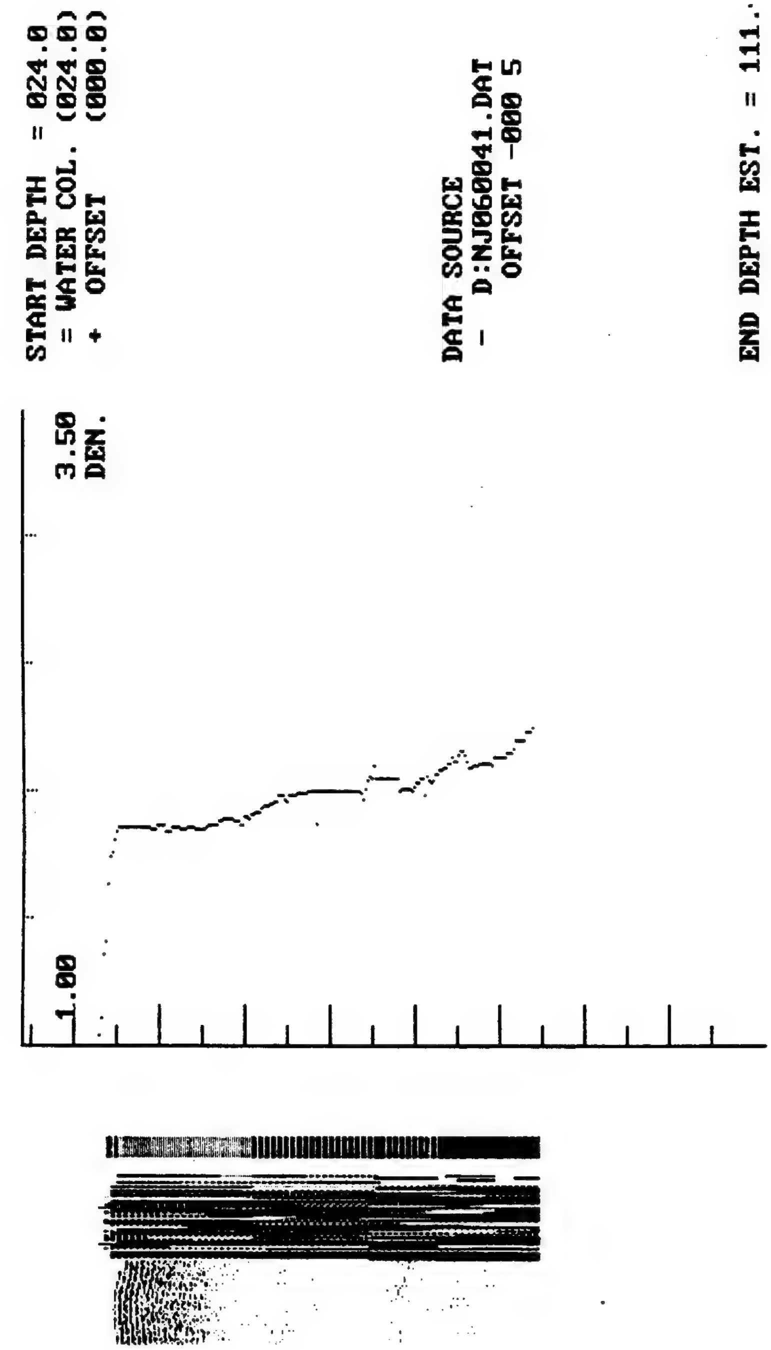
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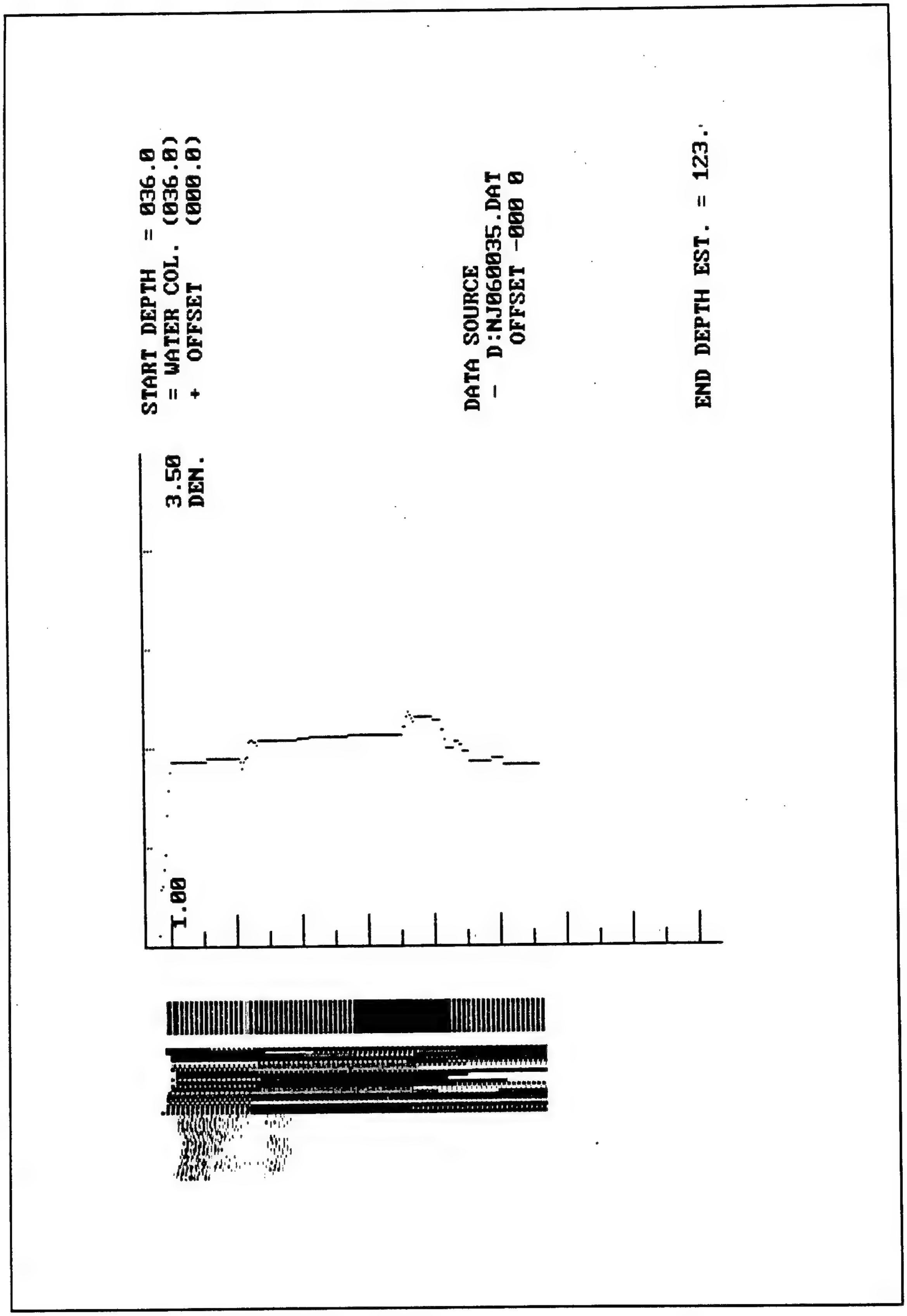
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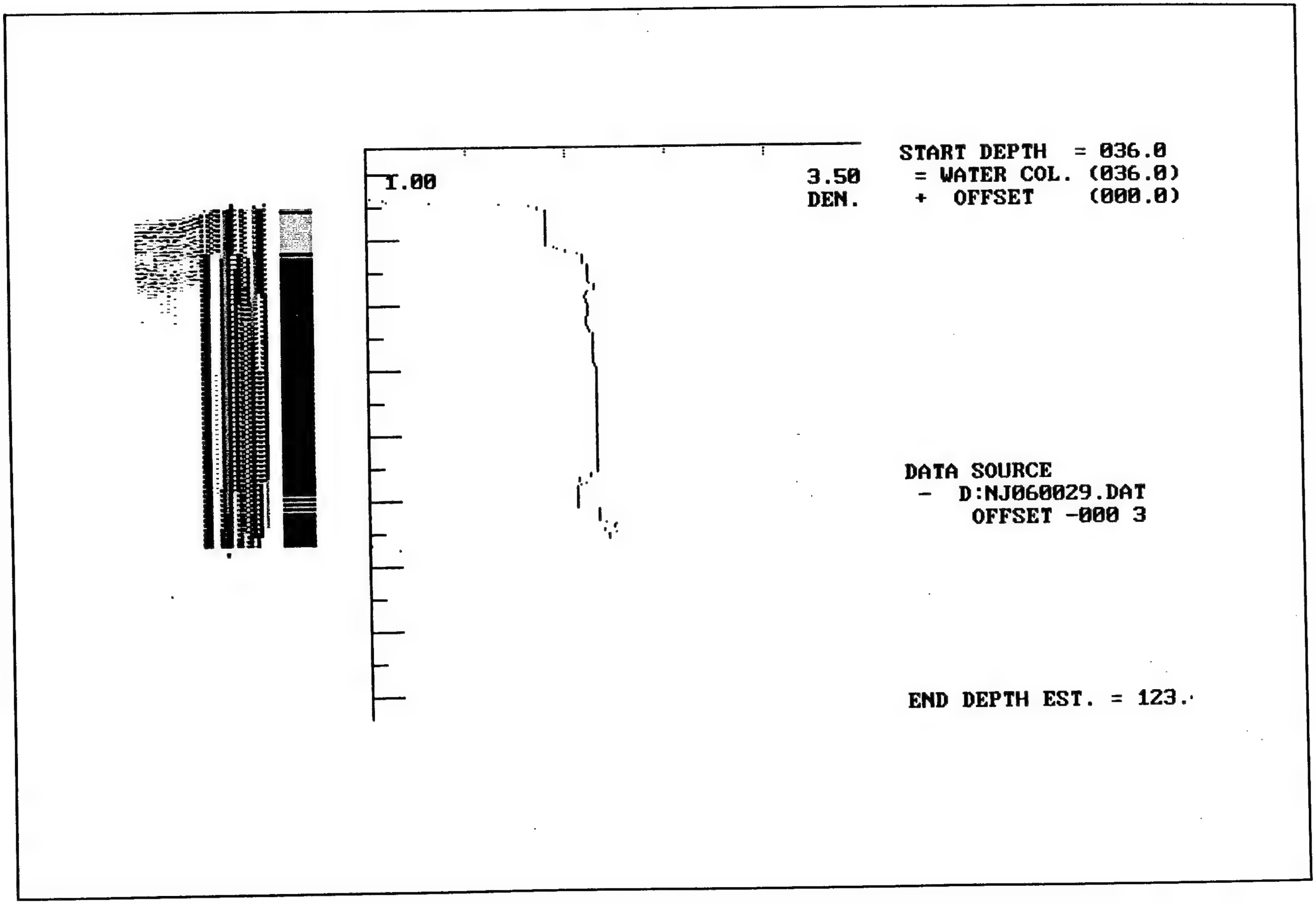
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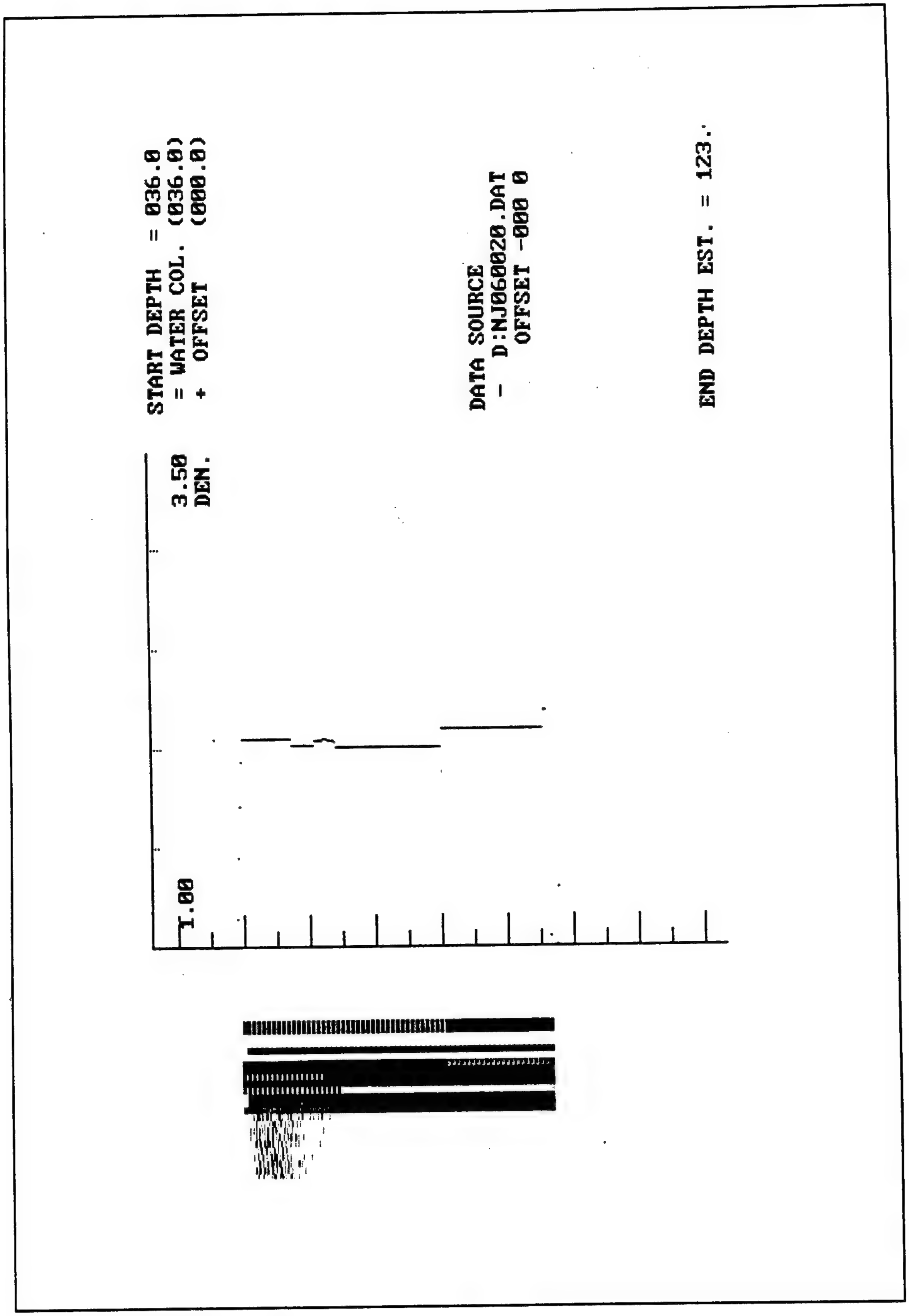
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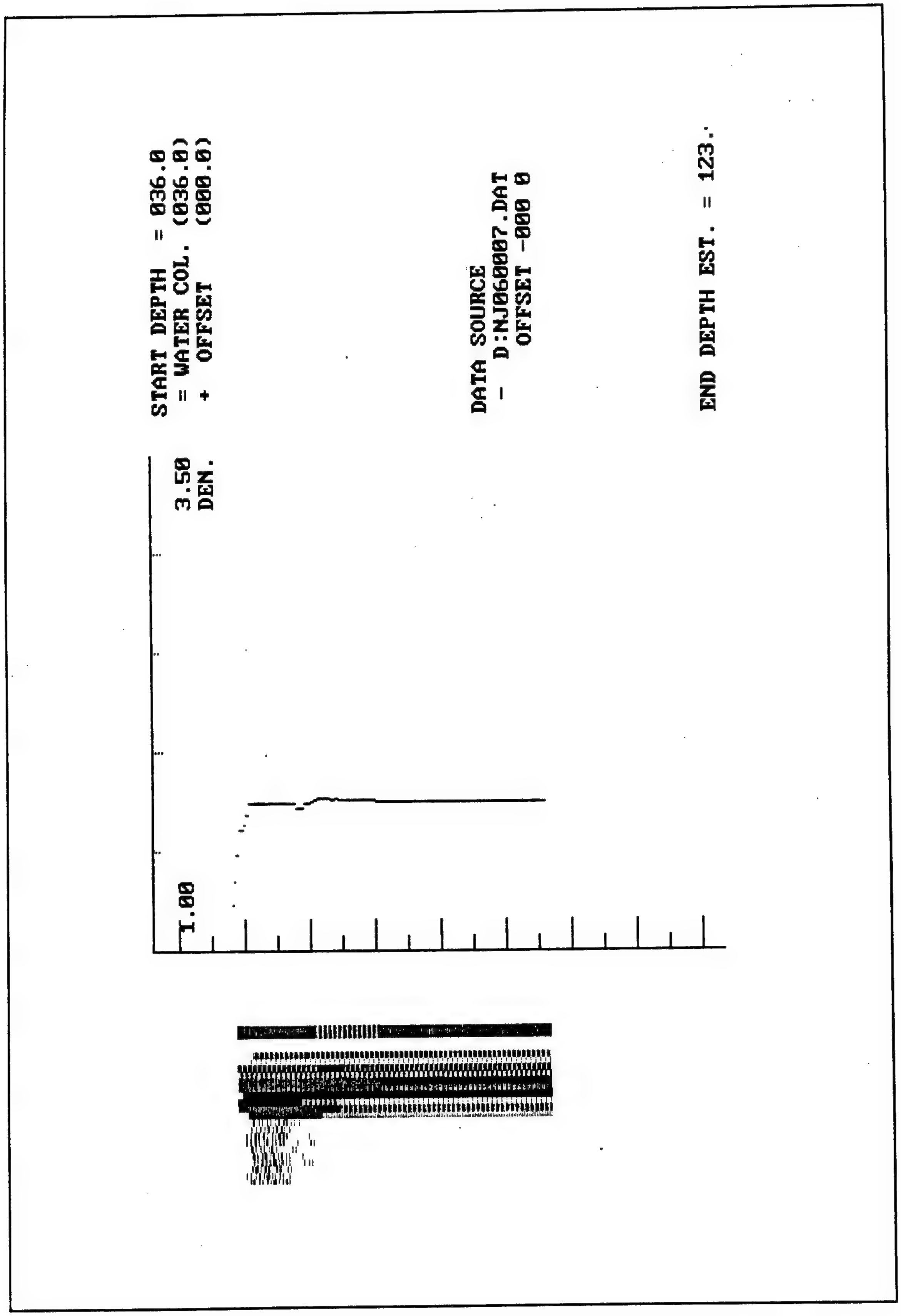
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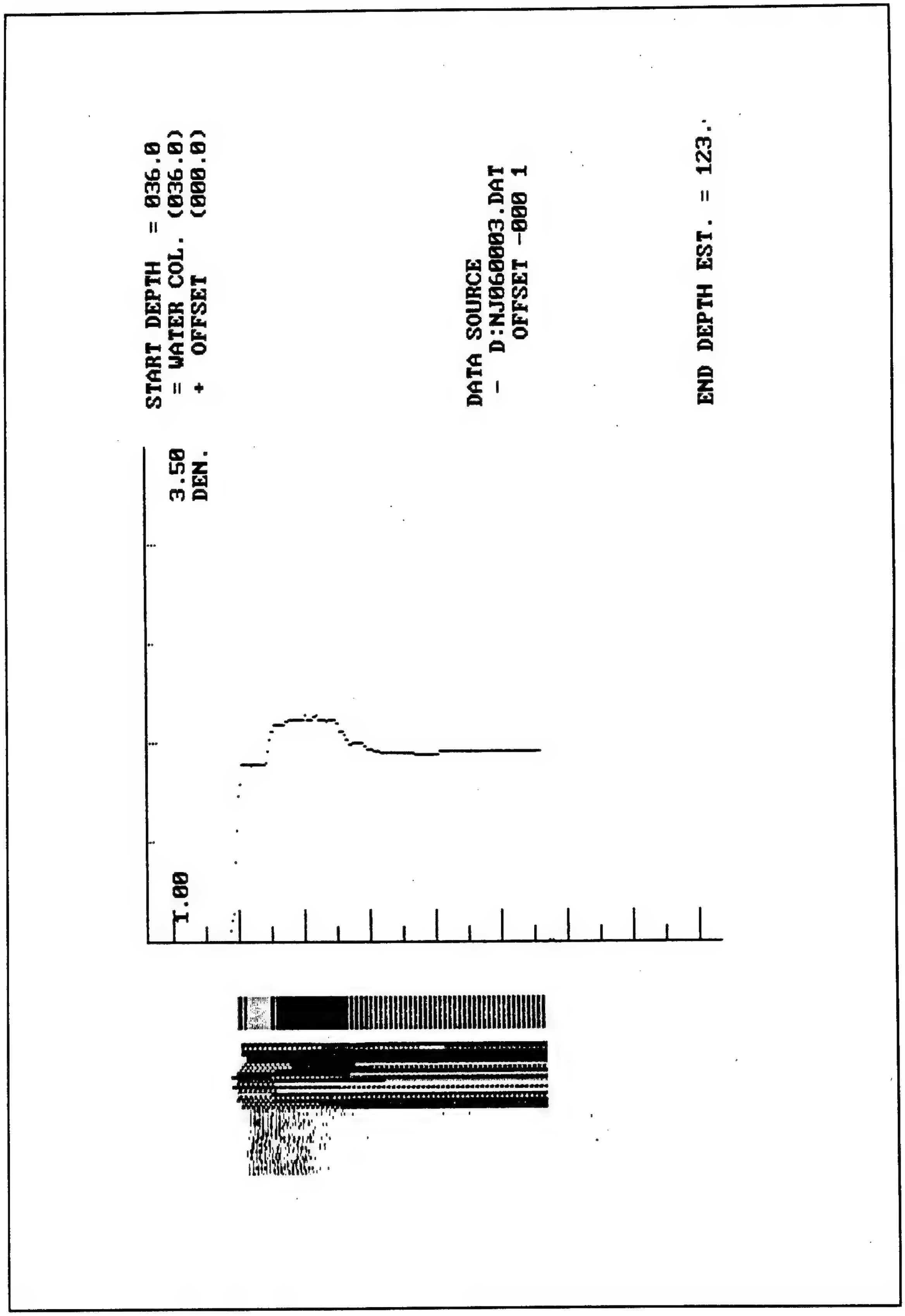
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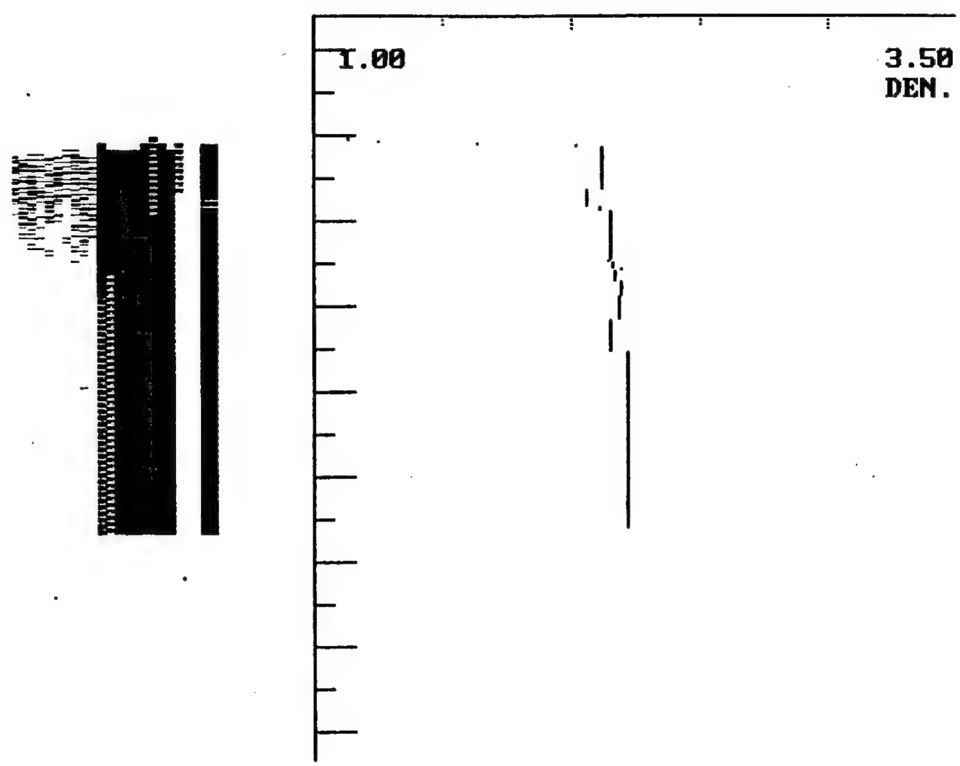

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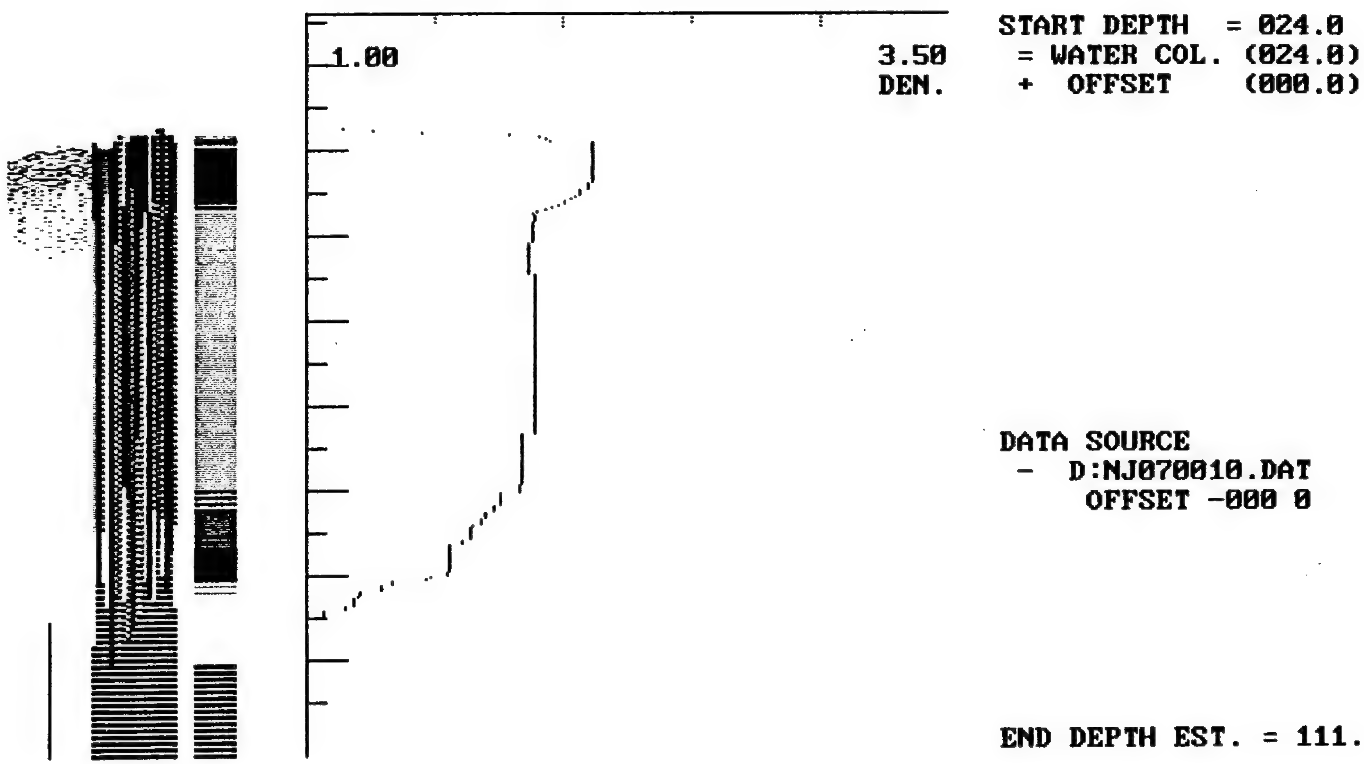
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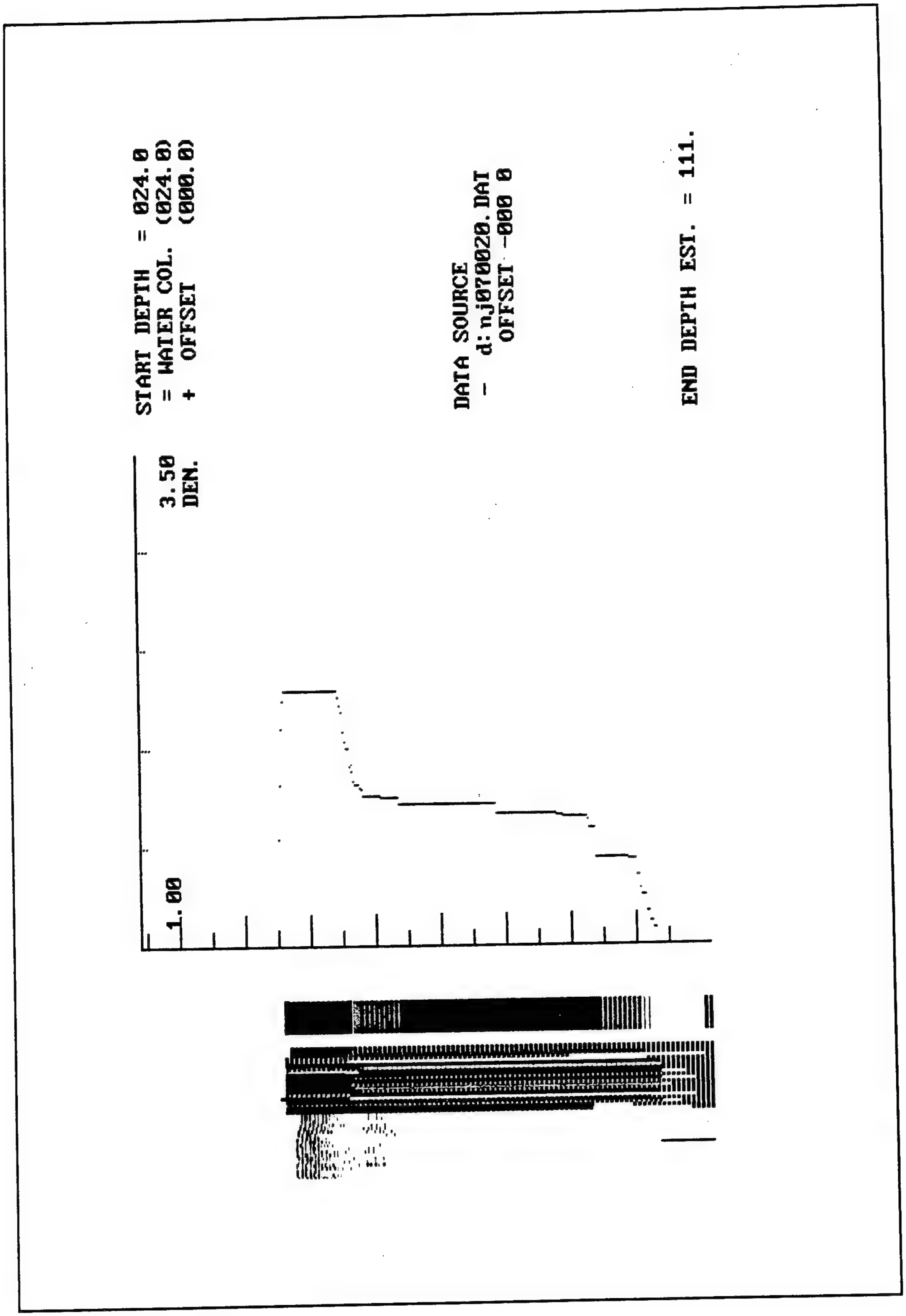
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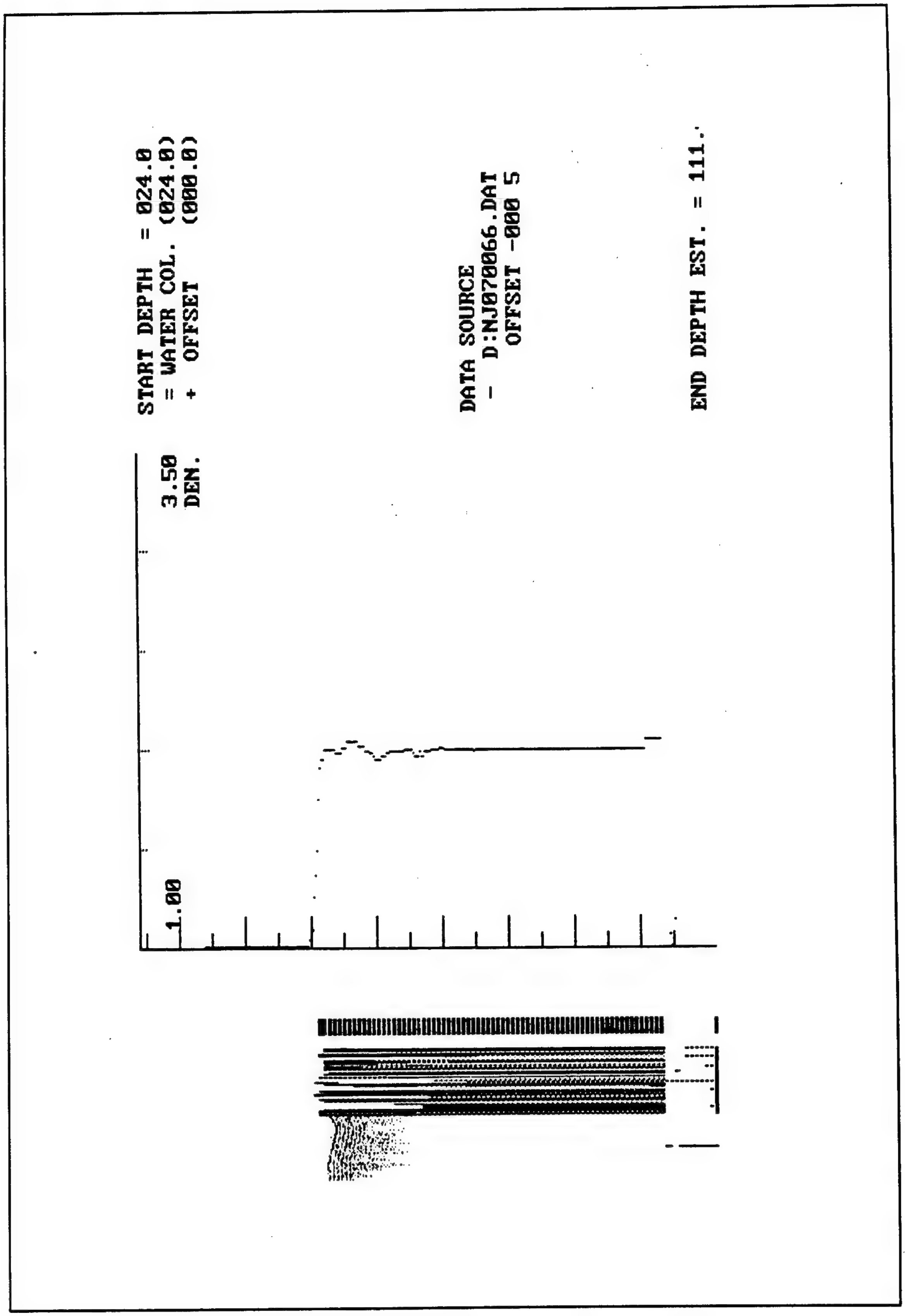
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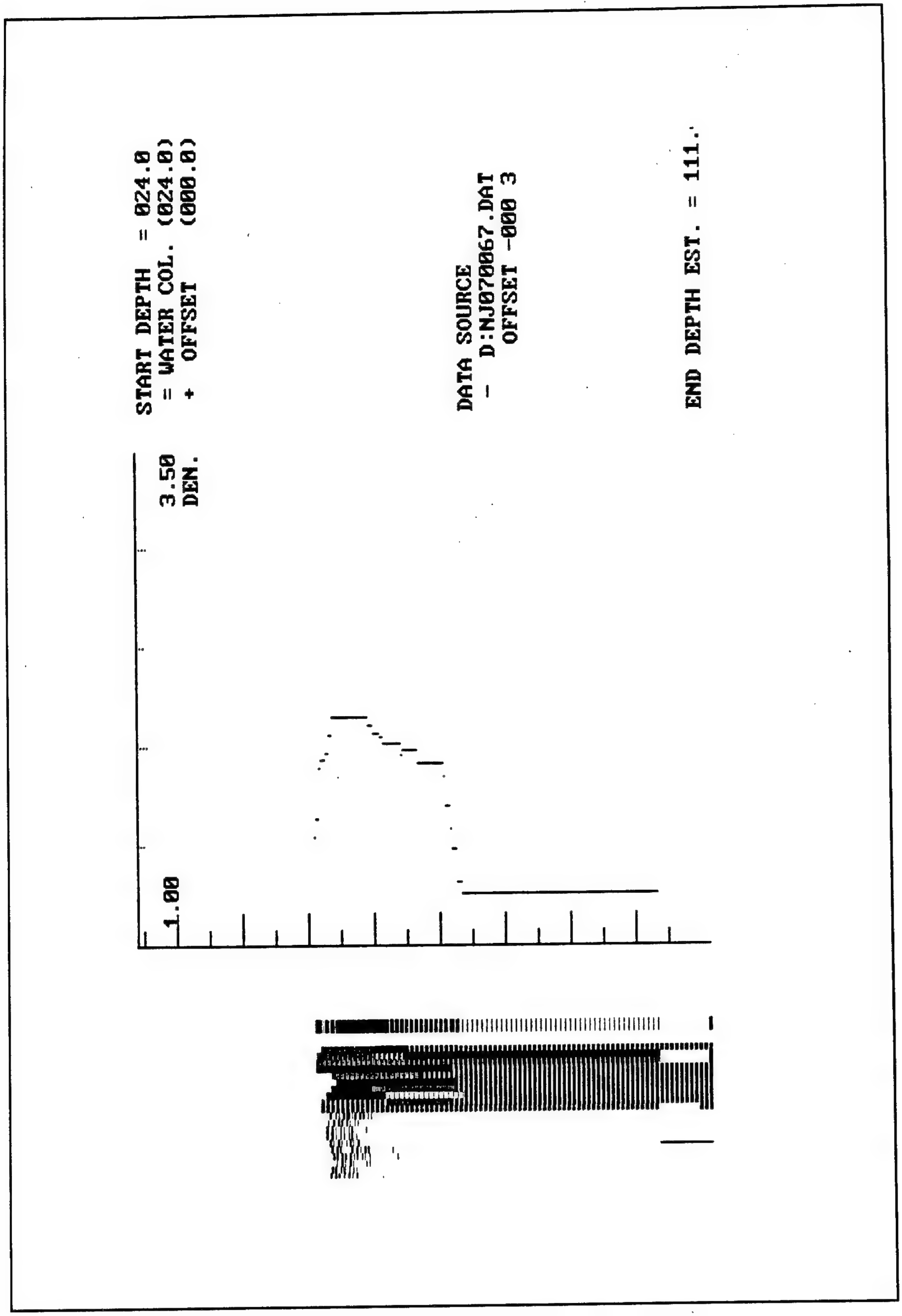
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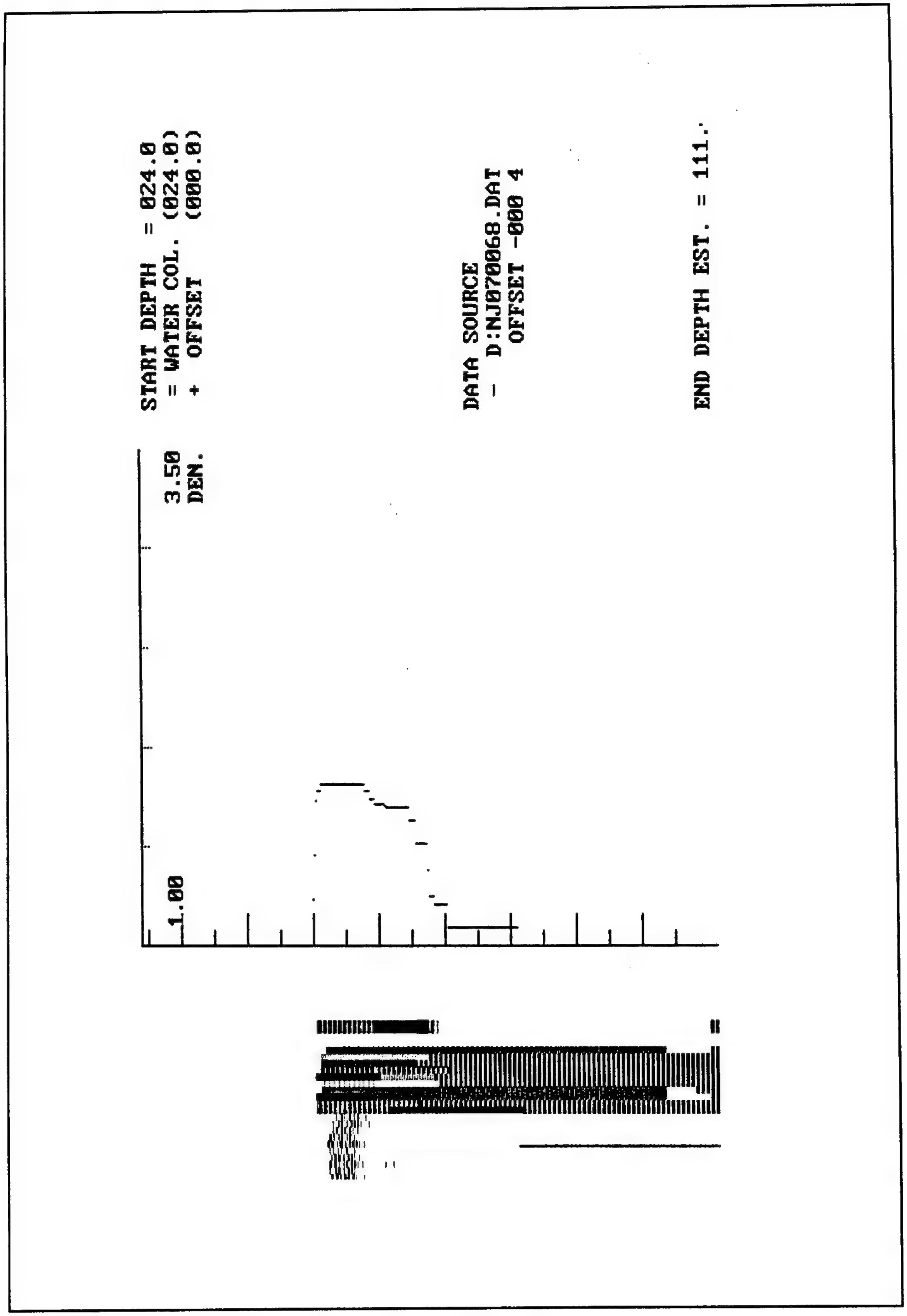
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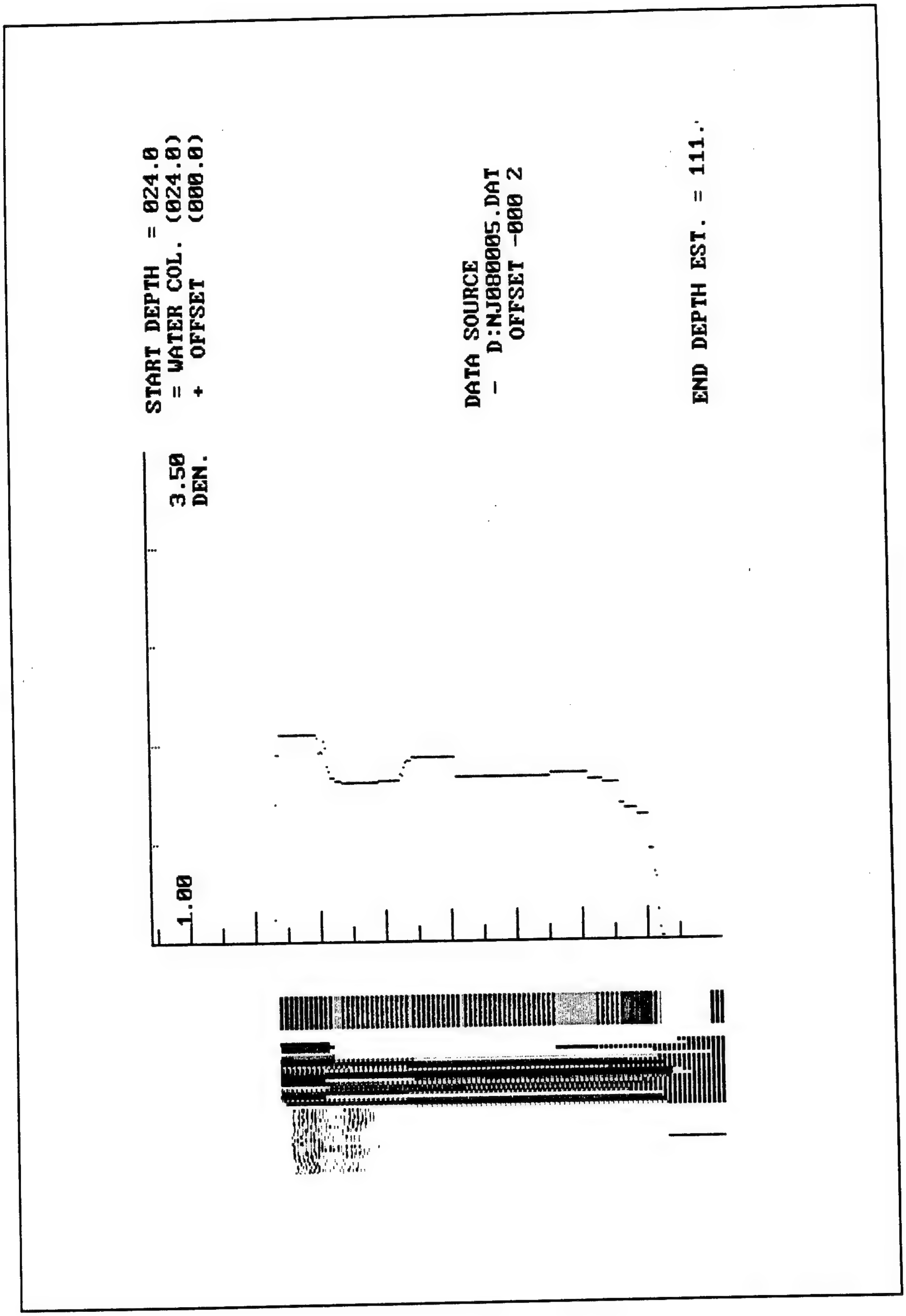
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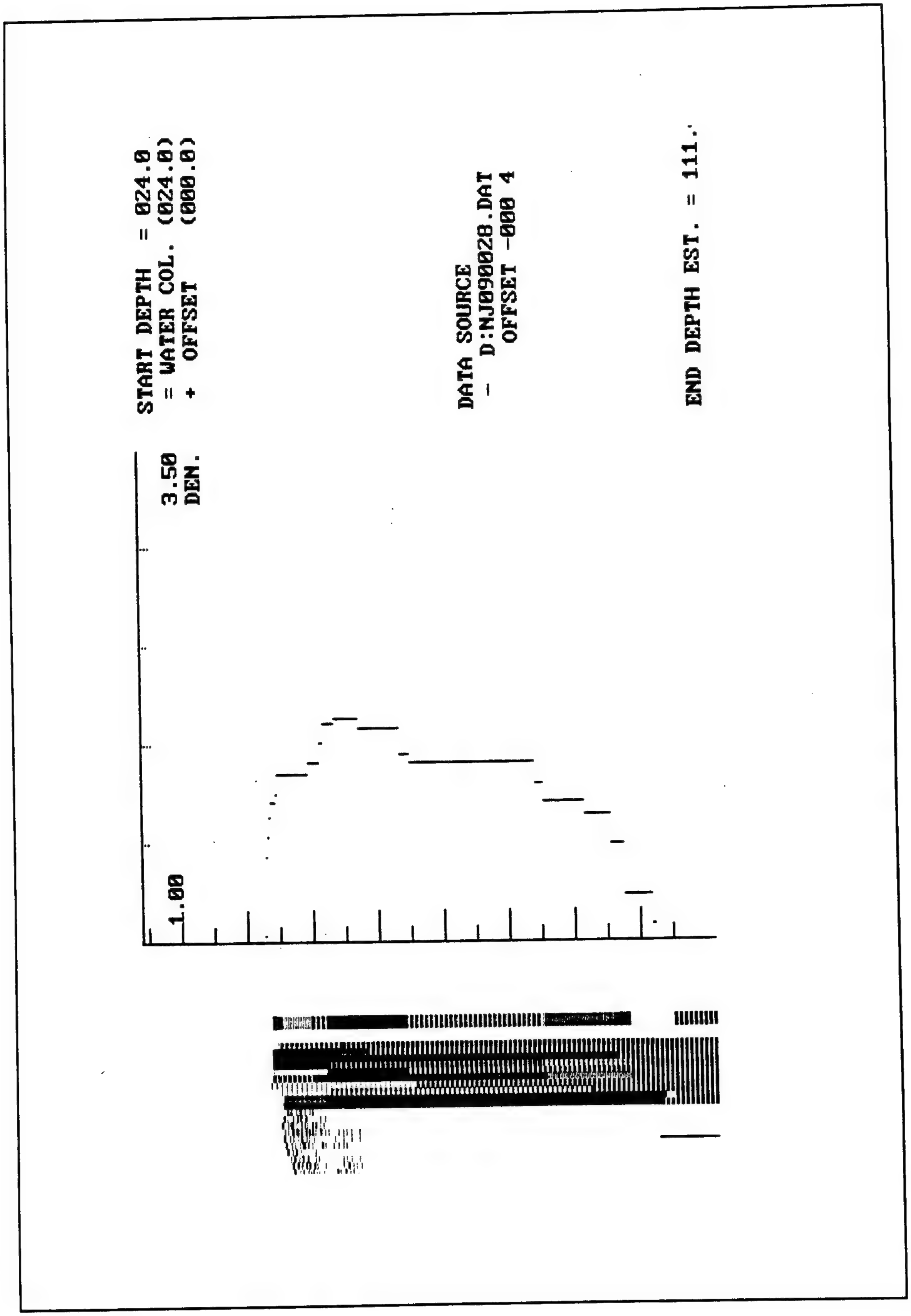
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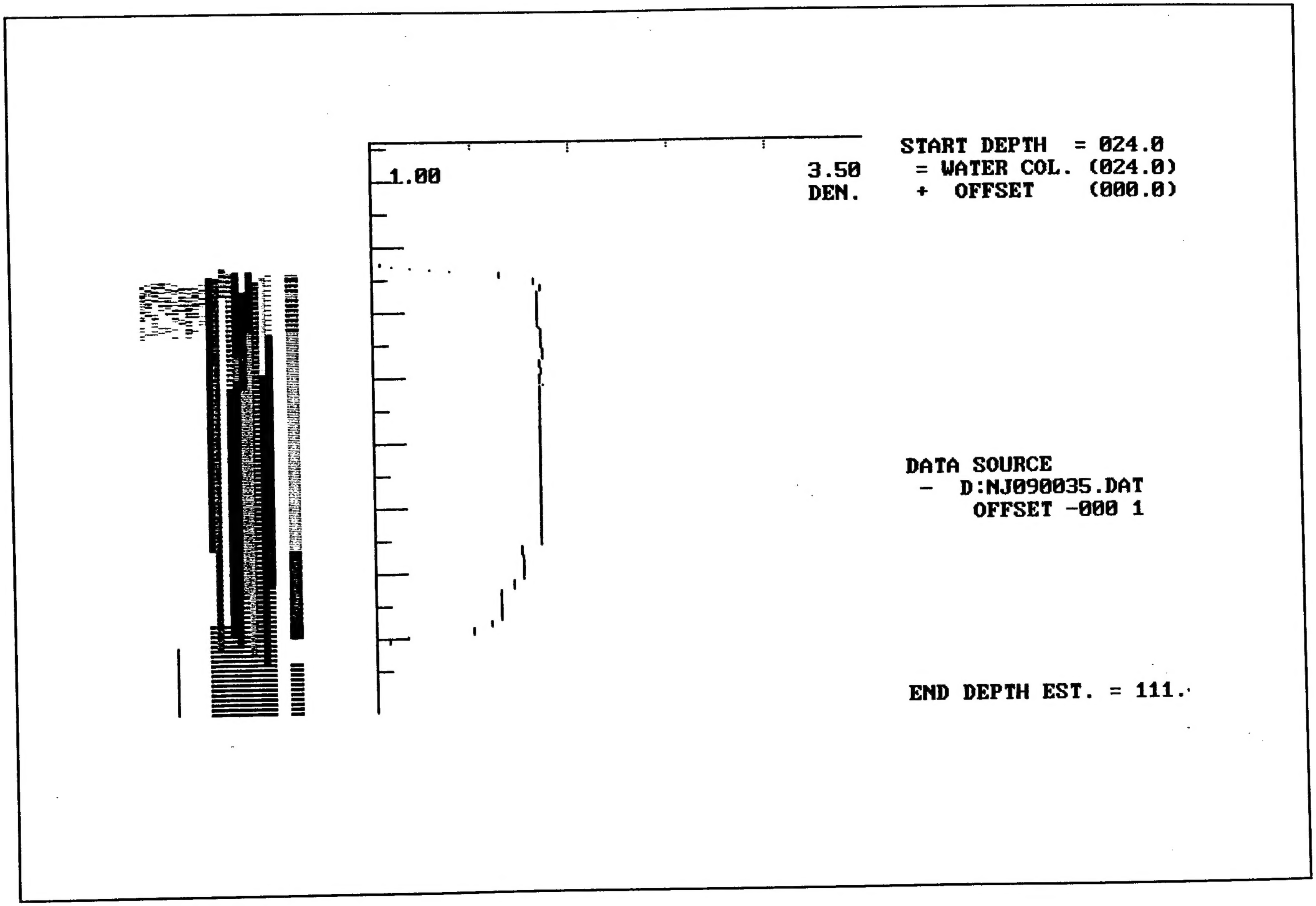
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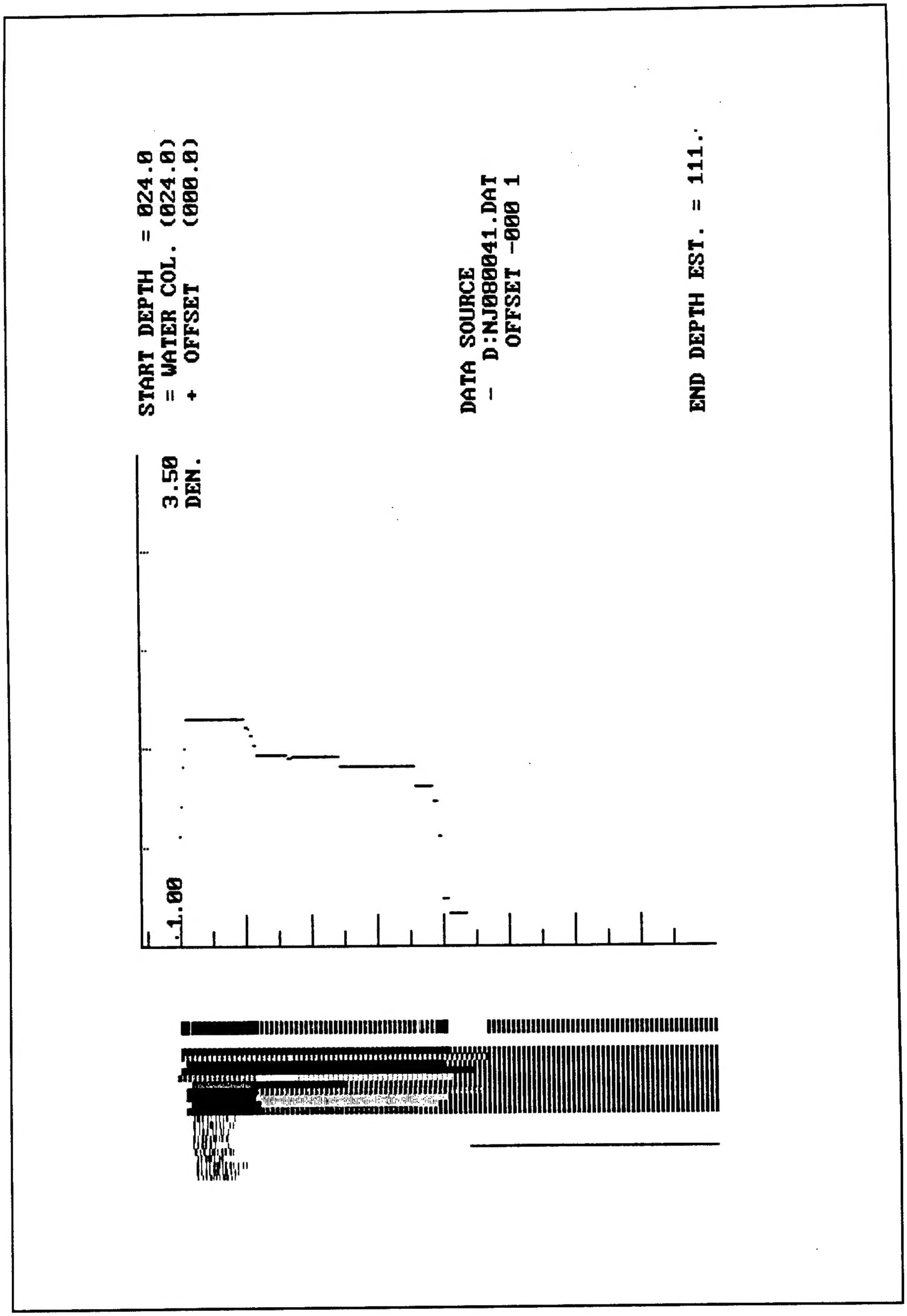
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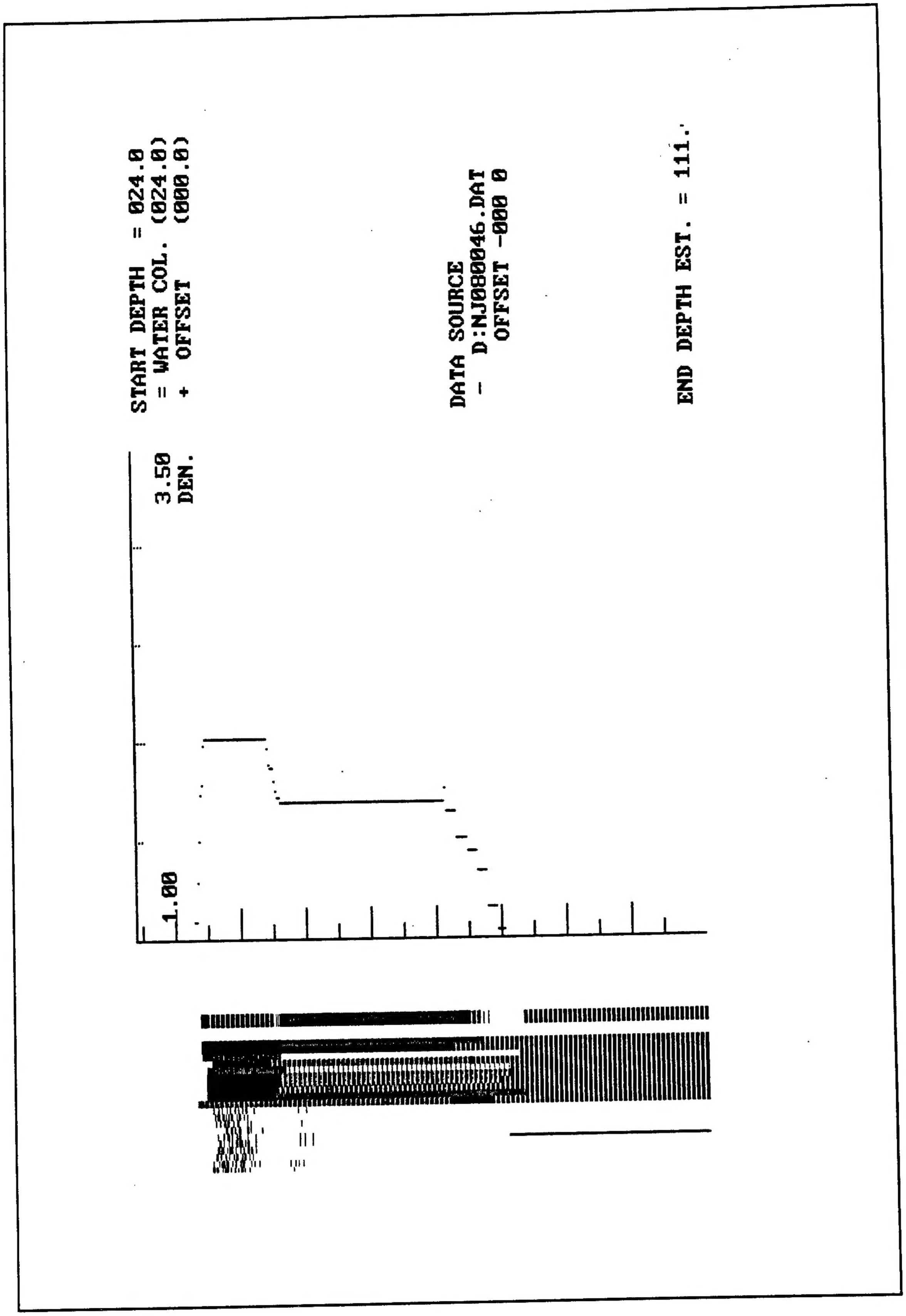
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13.ABSTRACT ***(Maximum 200 words)***

A comprehensive geoacoustic study has been performed for a 7-mile stretch of coastline off the coast of New Jersey between Townsends Inlet and Hereford Inlet for the purpose of defining the limits of available granular materials. The work was performed in support of the U.S. Army Engineer District, Philadelphia's, feasibility study for shore protection solutions for the Atlantic coast of New Jersey. Specifically, the objective of this investigation was to quantify the bottom and subbottom sediments in terms of in situ density, mean grain size, and soil type from the seafloor surface to a depth of about 20 ft below the bottom, where possible, providing initial estimates of the sediment characteristics as related to their potential use as beachfill material. A high-resolution acoustic reflection technique was used to quantitatively assess the characteristics of the naturally occurring marine sediments. Analysis of 3,500-Hz and 1,000-Hz seismic reflection data in conjunction with vibracore sampling data from selected sites throughout the New Jersey coast study area has been completed. The seismic data were correlated with the laboratory analysis of the sample data through acoustic impedance and acoustic absorption analysis. This being a reconnaissance level study, the results are not intended to assess the suitability of any marine sediment as beach quality material; rather the results are intended to pinpoint areas for further detailed investigations.

14.SUBJECT TERMS
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Geophysical methods
Marine sediments

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